Digital Design in Urban Environments

digital design

in urban environments

TAMPERE UNIVERSITY OF TECHNOLOGY

Tampereen teknillinen yliopisto - Tampere University of Technology

DIGITAL DESIGN IN URBAN ENVIRONMENTS
Explorations in Computational Design Strategies

ARK-54208 Digital Design in Urban Environments

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Lisa Voigtländer, Toni Österlund

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introduction

This book presents the various design explorations that architecture students did during the Digital Design in Urban Environments course, held at the Tampere University of Technology within seven weeks at the end of 2015. The course focused on the new possibilities that digital design methodologies provide, especially in the shift of thinking design through the use of algorithmic processes and parametric modeling.

During the course students tested and explored different computational design methods through small design tasks that were given after weekly lectures. The digital design platform we used was Rhinoceros 3D and its parametric design plugin Grasshopper. The goal of the course was to provide the students a broad view onto the subject and the challenges they pose, but in a way that they can acquire the necessary information and skills to implement the new tools and methods in their own design processes.

As the teacher, it is crucial for me that the students learn the methods through their own designer identities and explore their significance to themselves and to their way of working. It is not about just copying given solutions and methodologies, but finding new ways of doing and especially thinking architectural design. That is why I urged them to explore widely and without fear (within this short timeframe) – sometimes even resulting in failure to live to the preconceived expectations of what they wanted. But when you bump into the boundaries of your skills and knowledge, you also expand them.

Toni Österlund

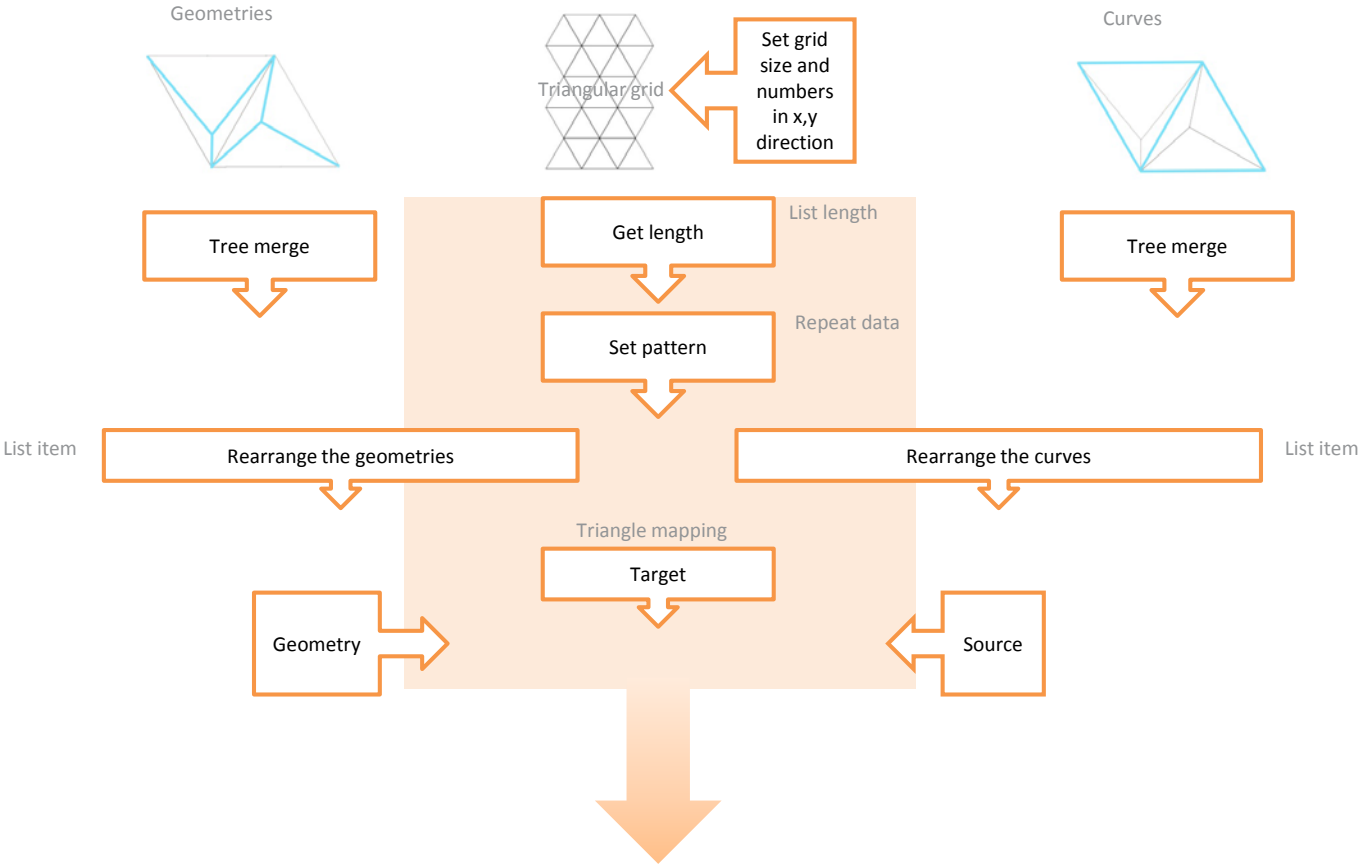
01 lists

During our first exercise, we followed the tutorial instructions and afterwards tried to modify the process or geometry in some way to come up with creative and aesthetic design solutions for three-dimensional façade elements.

01

_ authors

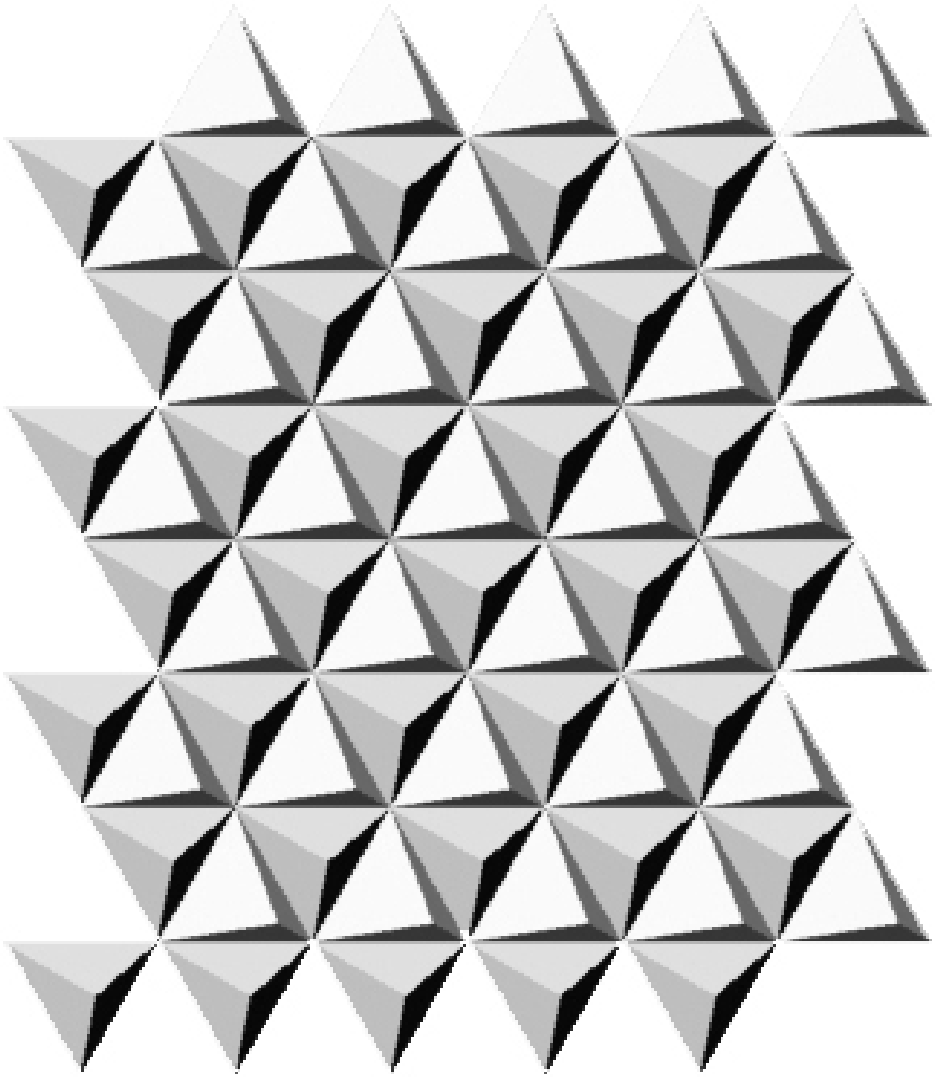
idea concept



line pattern

visual explanation

3D pattern



_ triangular grid

Lu Fan

The starting point of this practice is using “Lists” to create the pattern. I decide to use triangles as the basic shape. With some transformation, the motif is ready, which is composed of inner curve and triangular outline. Then the triangular grid is set with proper scale in x and y direction. Finally, the inner curve as geometry, outer triangle as source, and the grid as target are rearranged by triangle mapping and the pattern is done.

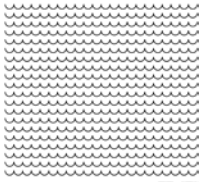
As the shape of motif reminds me of a pyramid, I tried the 3D pattern with the same procedures. The 3D pattern turns out to be an uneven “diamond” surface.

Then, I tried to apply the line pattern to a curved surface by rectangle mapping, so the line pattern itself forms fluctuation according to the rise and fall of the curved surface. With similar steps, the pattern is also applied to the curved surface and tower surface to affect the façade openings by the pattern.

idea concept

patterns


_ 01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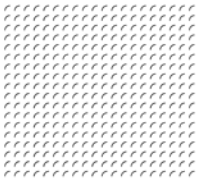
_ 03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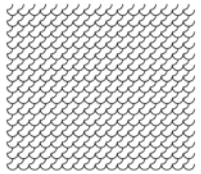
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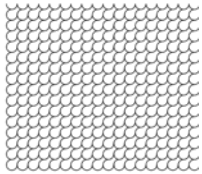
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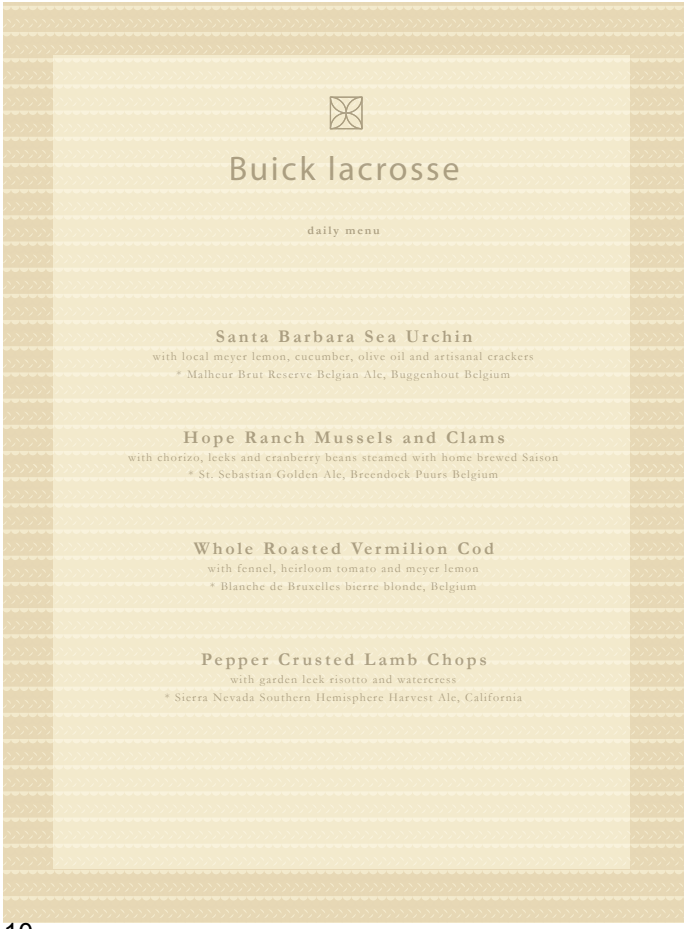
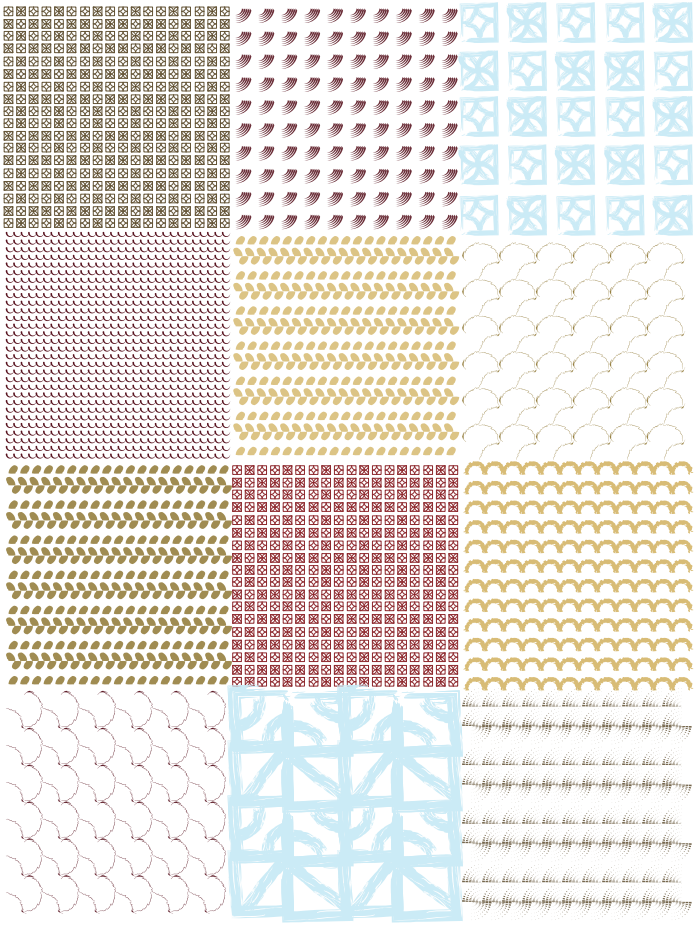
patterns re-used in restaurant menu graphics

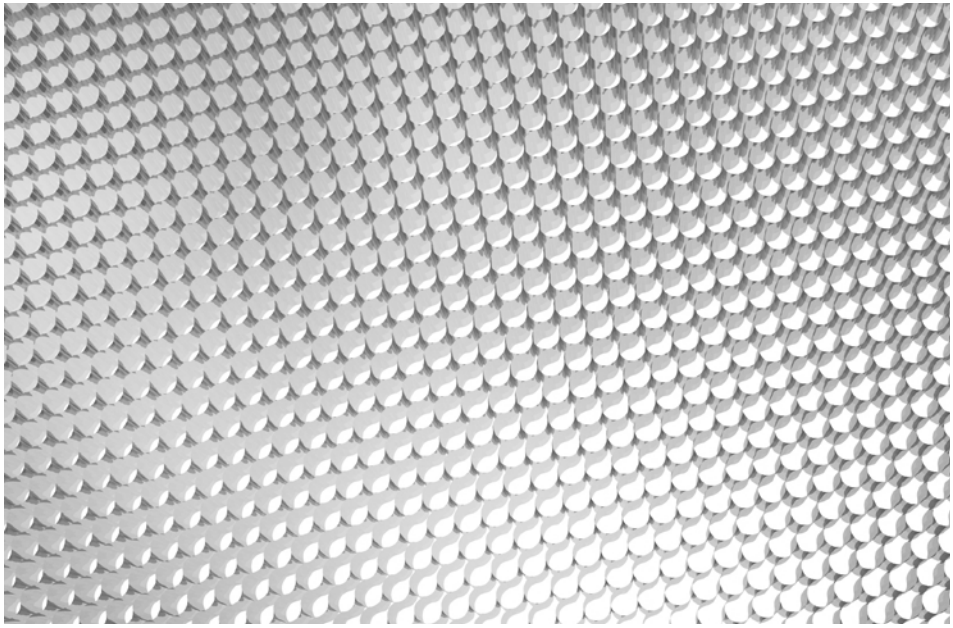


patterns re-used in fabric graphics

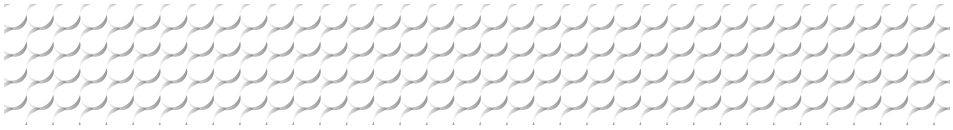


visual explanation

patterns extruded into 3D



patterns re-used in business card



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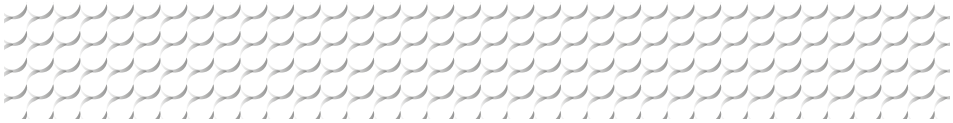


_ ringlet design

Petra Moravcova

I would have liked to use the Grasshopper patterns for the 2D graphic design mainly. I created two main samples using different input of geometry and by changing the combination of numbers in the panel I obtained several ways of patterns I could use afterwards in creating distinguished stuff as business card, restaurant menu or fabric pattern. I also let them overlap each other to create even more usable patterns.

Using variety of Adobe Illustrator brushes I achieved desirable cool designs. Some of the original patterns were extruded from lines and rendered then.

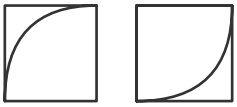
idea concept

2D patterns

PATTERN/ 1

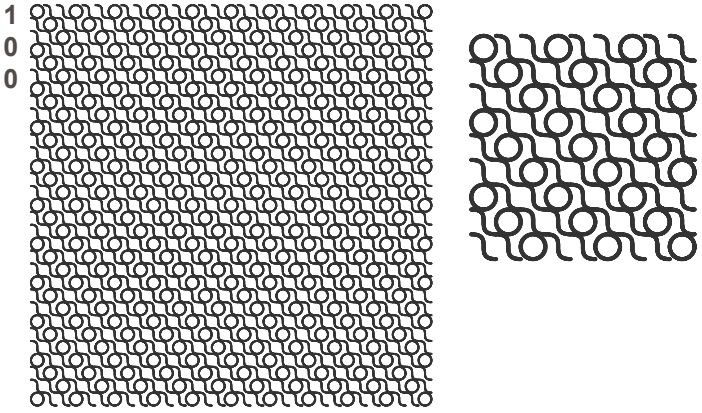
PATTERN/ 2

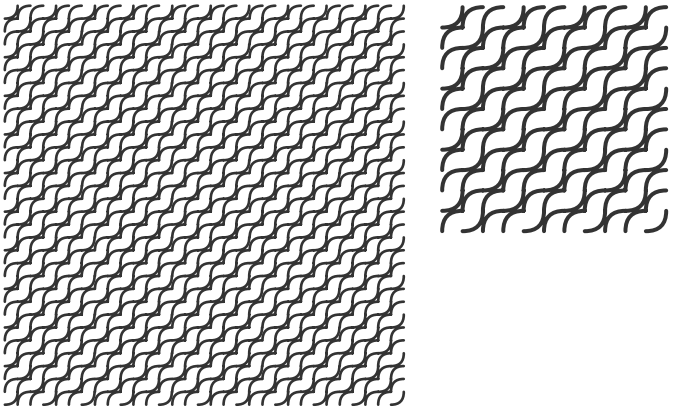
BASIC UNIT / GEOMETRY AND SHAPE

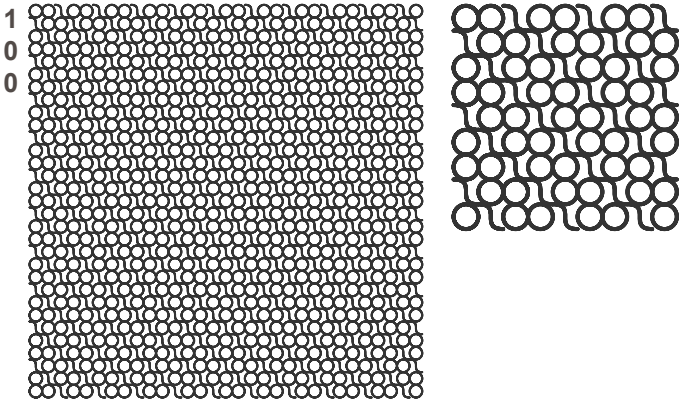


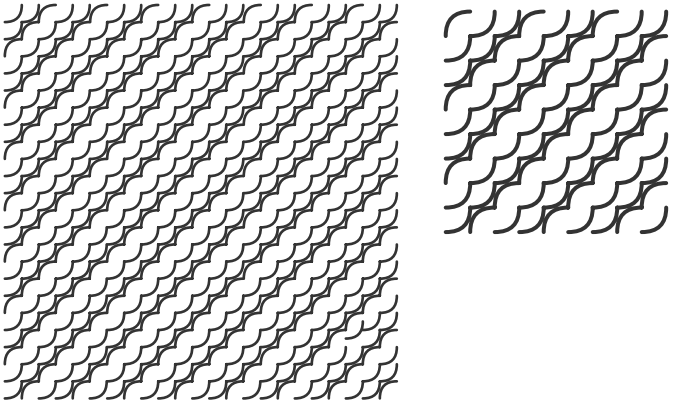
DESIGN

panel:



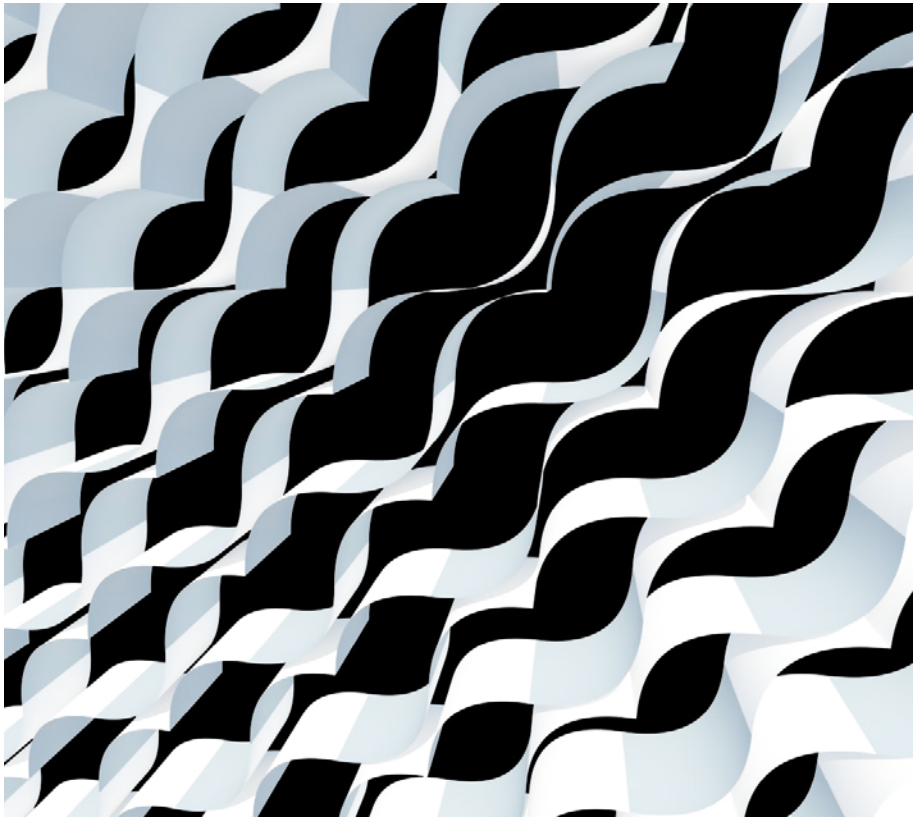


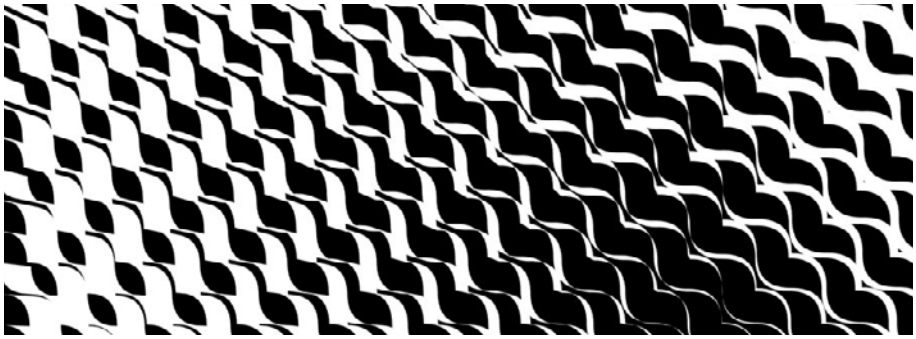




visual explanation

3D pattern





_ wave kiss

Danuta Kiedrowska

At the beginning of the work, I chose as a basic unit four combinations of shapes and geometries. In pattern / 1, it is created by squares, circle and wave, and pattern / 2 uses squares, and two arcs.

Using various combinations of the values in list item, I obtained different patterns, which could be easily changed . For the visualization I chose my second pattern, because of universal and ambiguous design.

From the beginning, it reminds me of sea waves, but on the other hand, we can observe also lips'/ French moustaches' shapes. It gave me a wide range of usage. It could be implement as graphical layouts in books, business cards, boards, as well as, use in industrial design, for instance: furniture.

02 function(al) architecture

Knowing the basics of mathematics and different mathematical concepts are essential in solving complex design tasks through computational methods. But besides problem solving, there is also elegant beauty in equations and with this exercise we should explore the possibilities of different mathematical expressions and functions as basis for an urban plan, structure or landscape architecture.

Through experimenting and exploring different functions and combinations, we tried to achieve interesting design results.

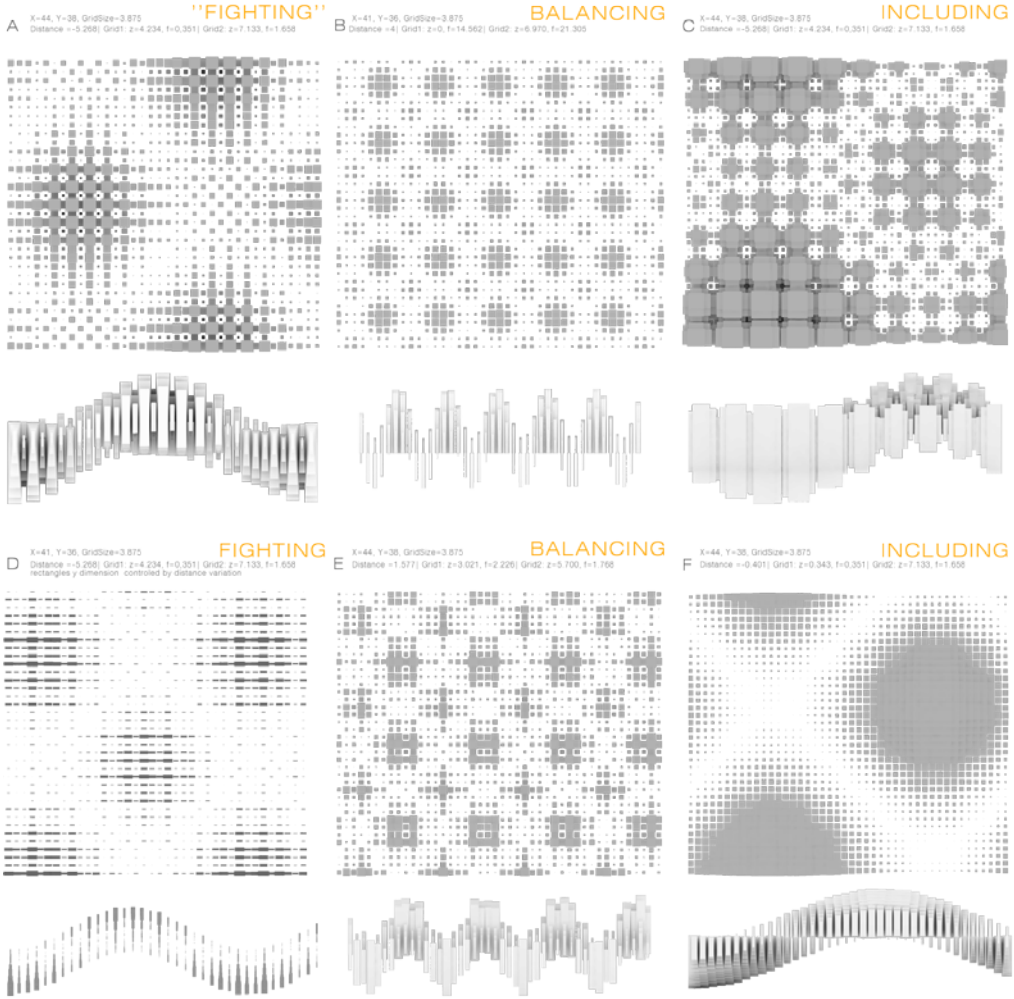
Testing out different possibilities that the Grasshopper components and the expression editor offers, we were seeking out a solution that satisfied us.

The main goal of this exercise was to familiarize us with the possibilities of mathematical equations and how to implement them in design.

02

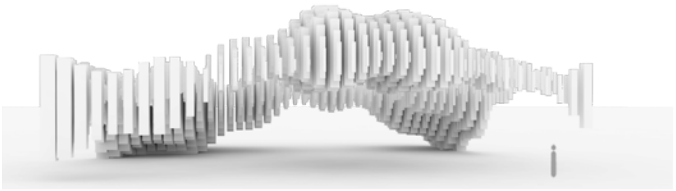
_ authors

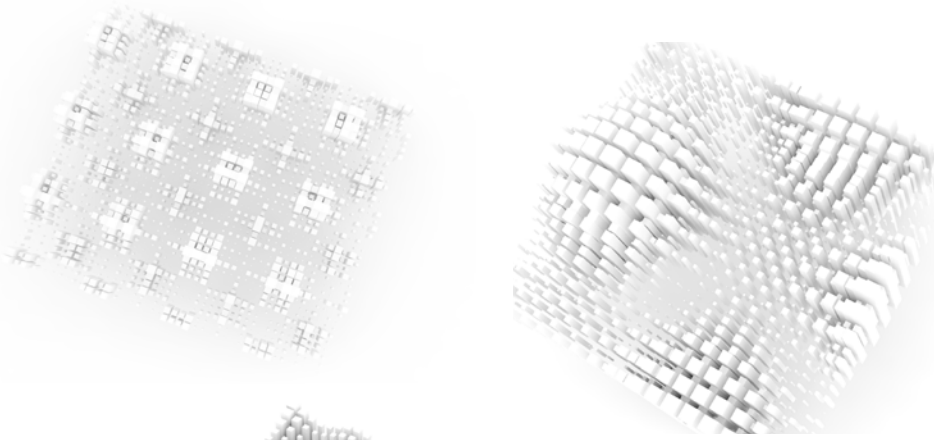
idea concept

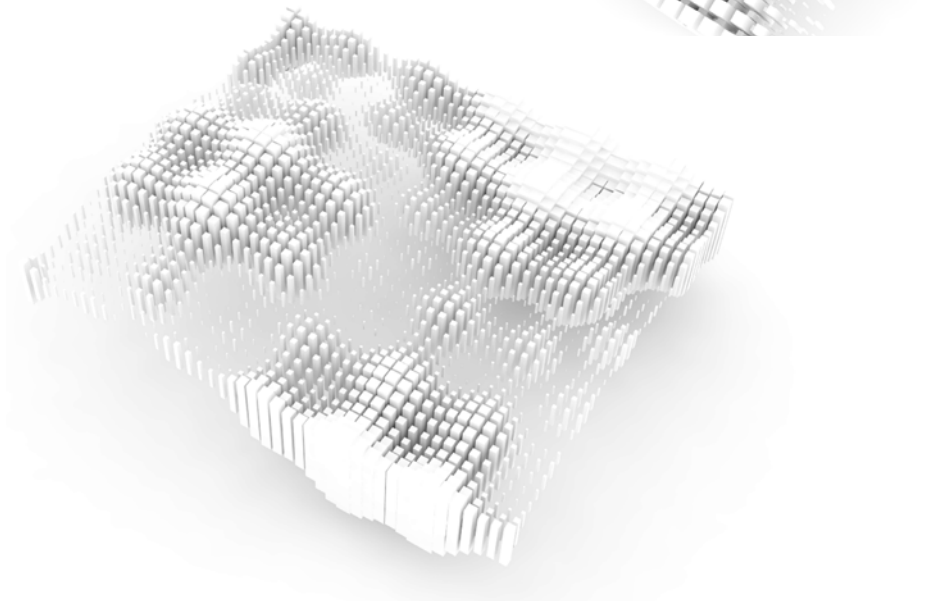


Through controlling the interfering of two sets of trigonometric grid points, several statuses of relationships could be observed: containing, balancing and fighting. When trigonometric grid points with longer and shorter frequency intersected with each other, the outcome embodied both fixtures obviously in one form, in which we can see the two original rhythm clearly (see C and G).In balancing status the two forces coexists and creating more averaging dense. In fighting stage the power of two trigonometric were taking control in different parts, for example, in A, smaller rectangles insert in larger ones, displaying the overlapping situation of closer and farer distance.

visual explanation







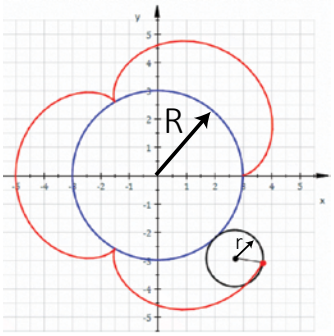
_ dynamic architecture

Lu Peixuan

Using grasshopper to try parametric design for me is a rather new and exciting thing. During the experience I was amazed by the great potentials in creating romantic and innovative architectural forms. So in the exercise of functional architecture I implemented my ideas of creating dynamic architecture by interfering trigonometric functions controlled surfaces.

The main procedure is first to create two sets of trigonometric point grids, and relate the dimension of rectangular boxes with the shortest distance between point grids. The x and y sizes of unit boxes were determined by the distance of the two sets of trigonometric surfaces. The length displayed the distance between two grid points. Then the larger distance between two grid points, the loose boxes cluster.

idea concept



In the differential geometry of curves, a roulette is a kind of curve, generalizing cycloids, epicycloids, hypocycloids, trochoids, and involutes.
Roughly speaking, a roulette is the curve described by a point (called the *generator* or *pole*) attached to a given curve as that curve rolls without slipping, along a second given curve that is fixed.

The beauty of mathematics is presented in the exercise by making 'flowers' through parametric equations. I created algorithms using Grasshopper which allows to produce several kind of roulettes. Combining different parameters of **R** and **r**, different curves could be seen. In the next step simple 3D geometry based on roulettes is generated to present possibilities of using plane curve in design.

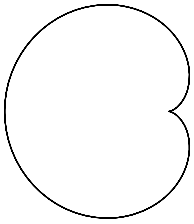
Source: https://en.wikipedia.org/wiki/Roulette_%28curve%29

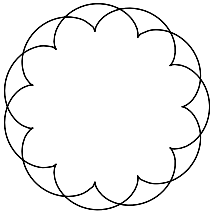
EPICYCLOID

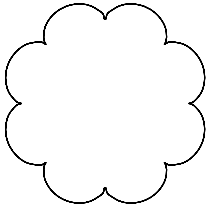
epicycloid is a plane curve produced by tracing the path of a chosen point of a circle — called an epicycle — which rolls without slipping around a fixed circle.

Parametric equation:
x=r*(k+1)*cos(t)-r*cos((k+1)*t)
y=r*(k+1)*sin(t)-r*sin((k+1)*t)

where k=R/r


R=5, r=5 - cardioid


R=11, r=2

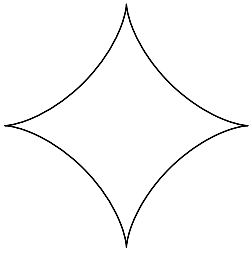

R=8, r=1

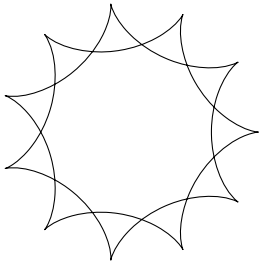
HYPOCYCLOID

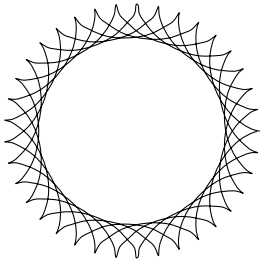
hypocycloid is a special plane curve generated by the trace of a fixed point on a small circle that rolls within a larger circle. It is comparable to the cycloid but instead of the circle rolling along a line, it rolls within a circle.

Parametric equation:
x=r*(k-1)*cos(t)+r*cos((k-1)*t)
y=r*(k-1)*sin(t)-r*sin((k-1)*t)

where k=R/r


R=8, r=2 - astroid


R=11, r=2

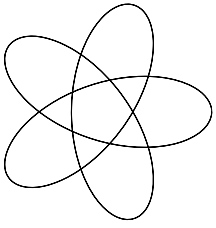

R=37, r=5

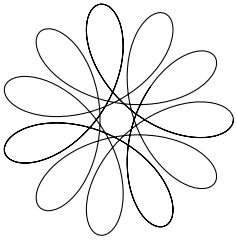
HYPOTROCHOID

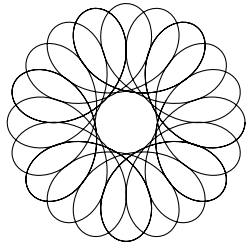
hypotrochoid is a roulette traced by a point attached to a circle of radius r rolling around the inside of a fixed circle of radius R, where the point is a distance d from the center of the interior circle.

Parametric equation:
x=r*(k-1)*cos(t)+d*cos((k-1)*t)
y=r*(k-1)*sin(t)-d*sin((k-1)*t)

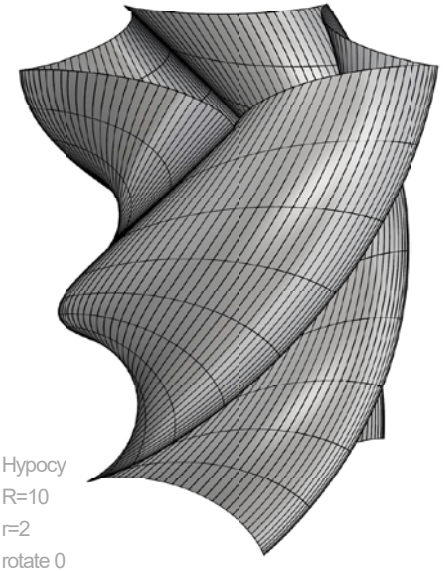
where k=R/r


R=5, r=2, d=5

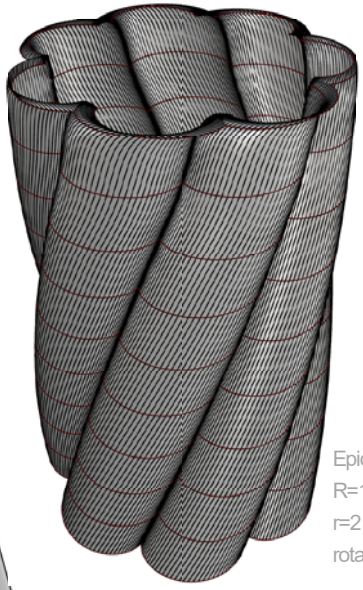

R=11, r=3, d=3


R=20, r=3, d=10

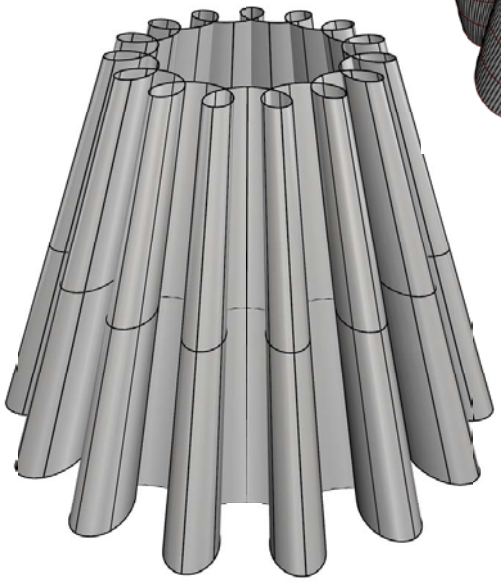
visual explanation



Hypocy
R=10
r=2
rotate 0



Epicycloid
R=14
r=2
rotate 0,5 Pi



Hypotrochoid
R=15
r=1
d=3

_ roulettes

Ekaterina Ishimova

In the differential geometry of curves, a roulette is a kind of curve, generalizing cycloids, epicycloids, hypocycloids, trochoids, and involutes.

Roughly speaking, a roulette is the curve described by a point (called the generator or pole) attached to a given curve as that curve rolls without slipping, along a second given curve that is fixed.

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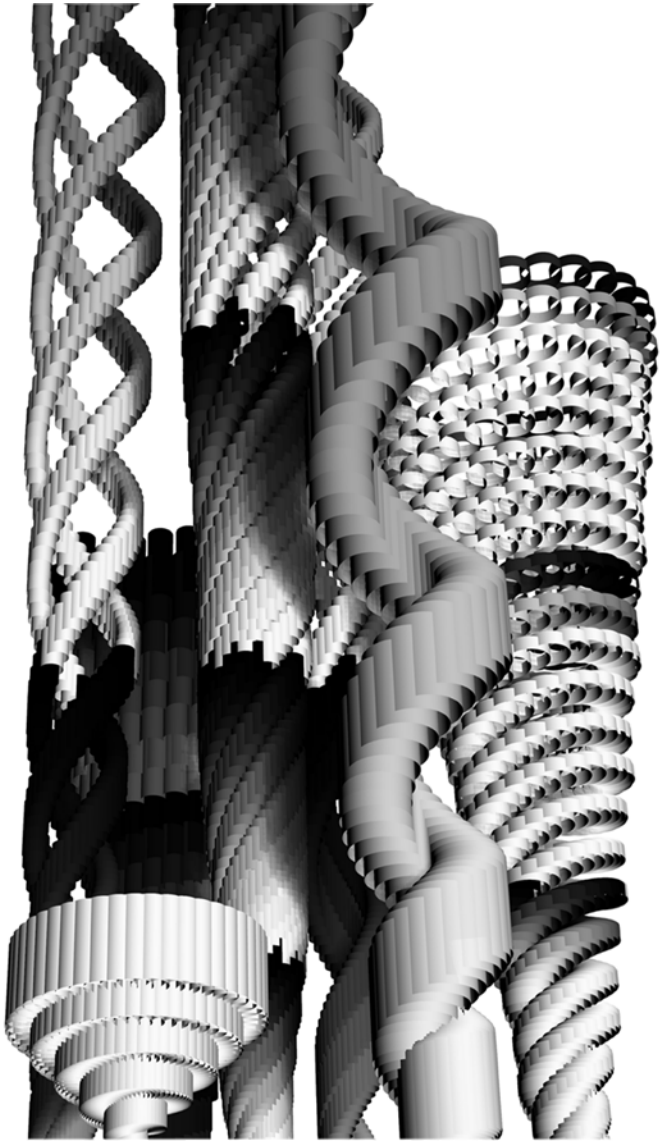
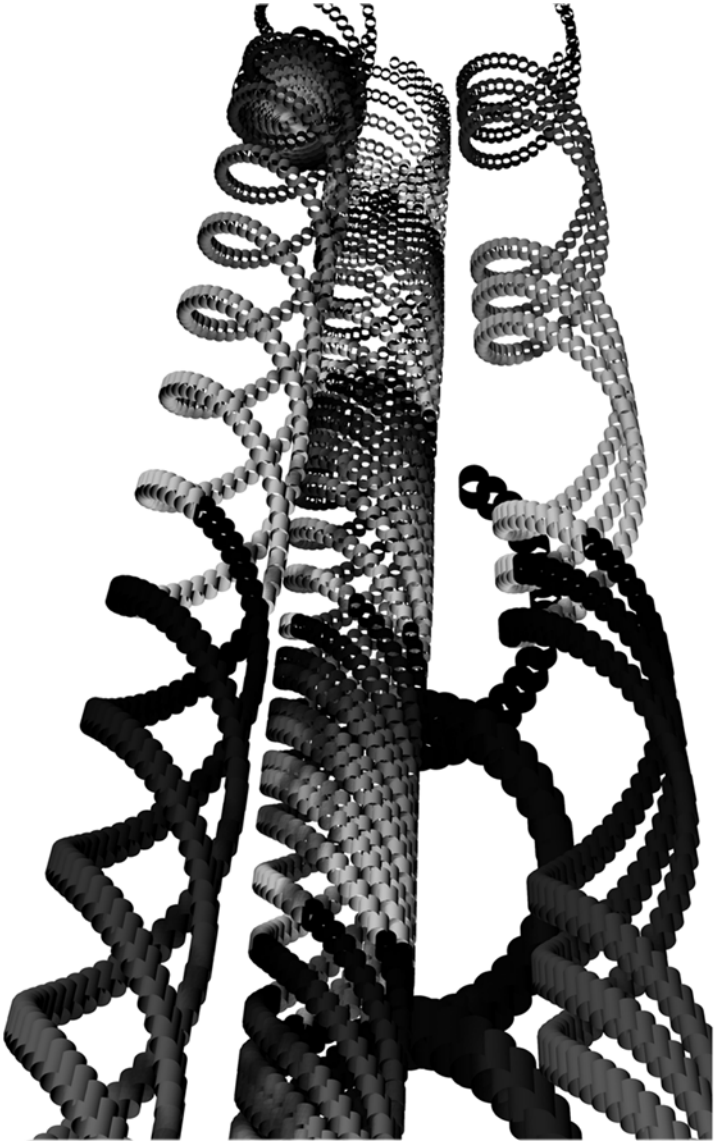
visual explanation

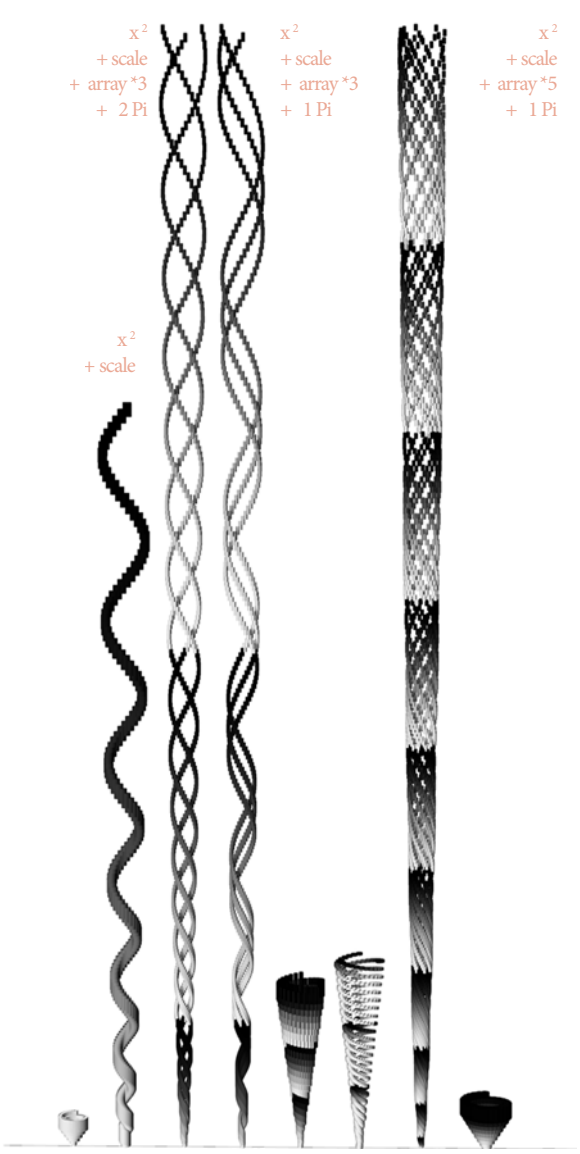
3D pattern

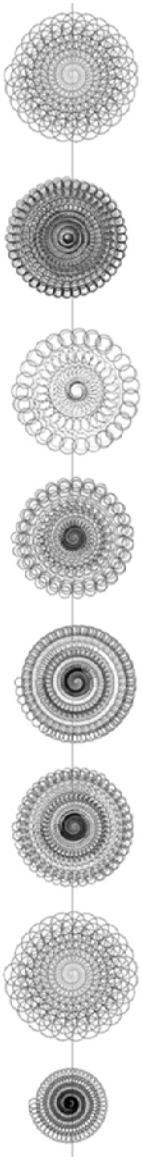




idea concept

mathematic equation





_ spiral in wonderland

Darina Bunak

The idea of my project was to investigate the possibilities of such a fascinating geometrical feature as spiral, especially in its 3D version.

I started with a classic definition for a spiral and then decided to add some volume to the structure by creating cylinders upon each point of the original curve. Thus, I received something reminding the upturned Tower of Babel or a seashell, which in terms of architecture usually serve as a source of inspiration for spiral stairs, ramps, arenas or atrium design.

It all resulted in apparently organic forms, which I multiplied by array function. Now, thanks to the elegant proportions, they could be used as prototypes for structures of all scales: skyscraper frameworks, flexible (earthquake-proof) steel columns or furniture legs.

03 attractive urbanism

During this exercise, we needed to select a certain location and map out different urban attraction factors it has. Next step was to define those factors either as point or curve geometries on top of an aerial image or map.

We chose a location within that map and design a small scale urban area (a building, urban furniture, or a landscape design) that utilizes the attraction field potential. Using the generated field, we defined density, orientation, height and scale of our design. The closeness to a certain point was used to increase or decrease defined parameters.

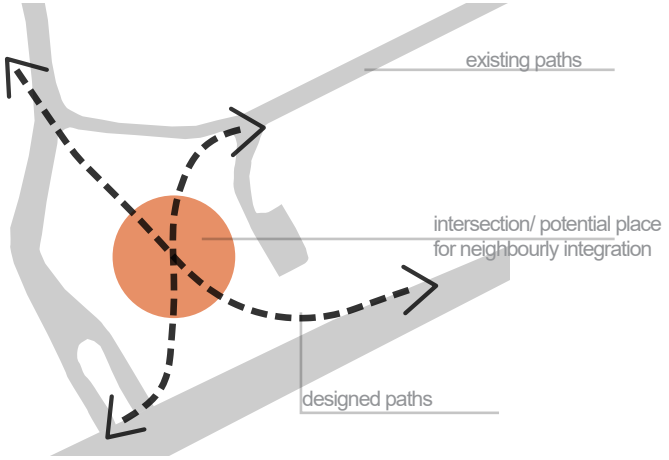
The main goal of this exercise was to familiarize us with attractors and their use as urban scale parameters and how to implement them in our design.

03

_ authors

idea concept

plot



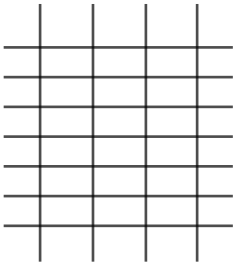
final plan

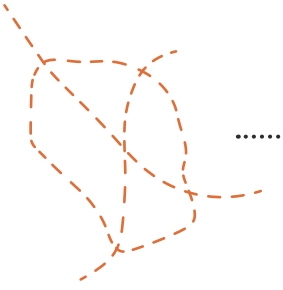
designing steps

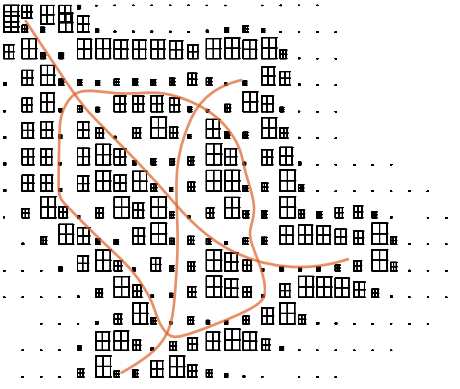
RECTANGULAR
GRID

TARGET
PATHS

CONNECTION

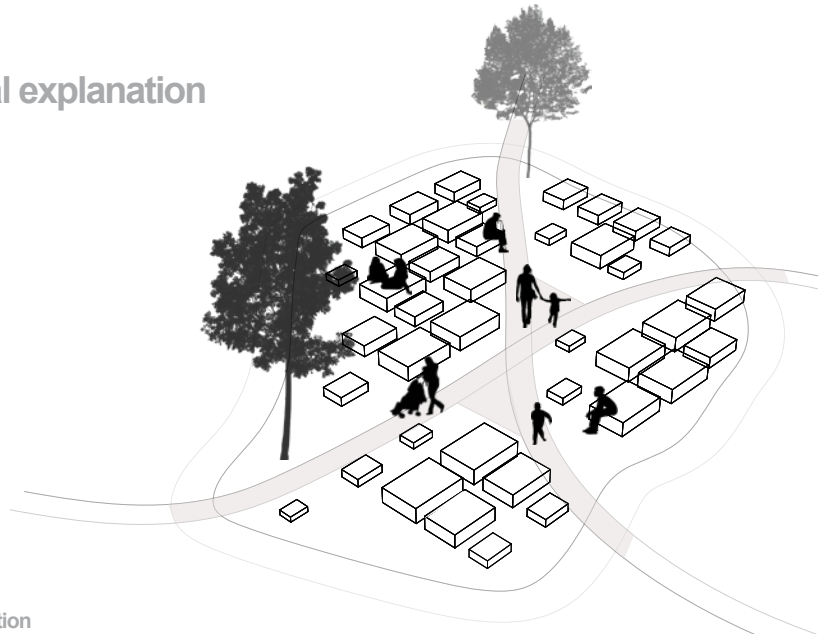






visual explanation

bird view



visualisation

_ INTERaction

Danuta Kiedrowska

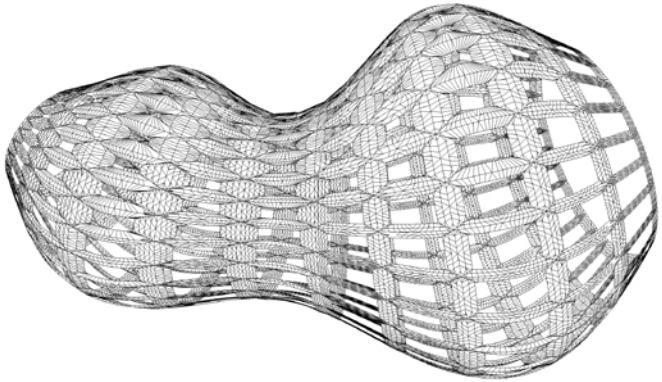
Thinking about urbanism, I keep in my mind social interactions between people. How in normal and daily environment, architecture could have impact on society and neighbours‘ reactions.

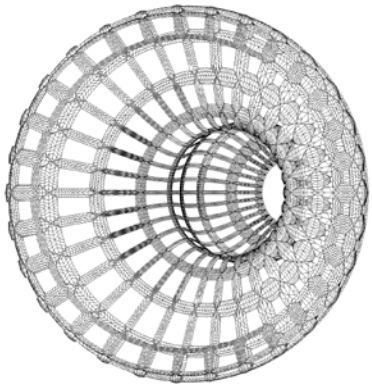
During this exercise, I decided to connect possibilities of Grasshopper and real needs, which appear in designed plot- empty space between average neighborhoods in Hervanta. I marked people‘s flows crossing the space- they created new paths, with a central intersection, as a meeting point.

As outcomes, I wanted to obtain irregular forms, which could be used as a multigenerational playground or a small common „park“, where inhabitants could easily rest during sunny days.

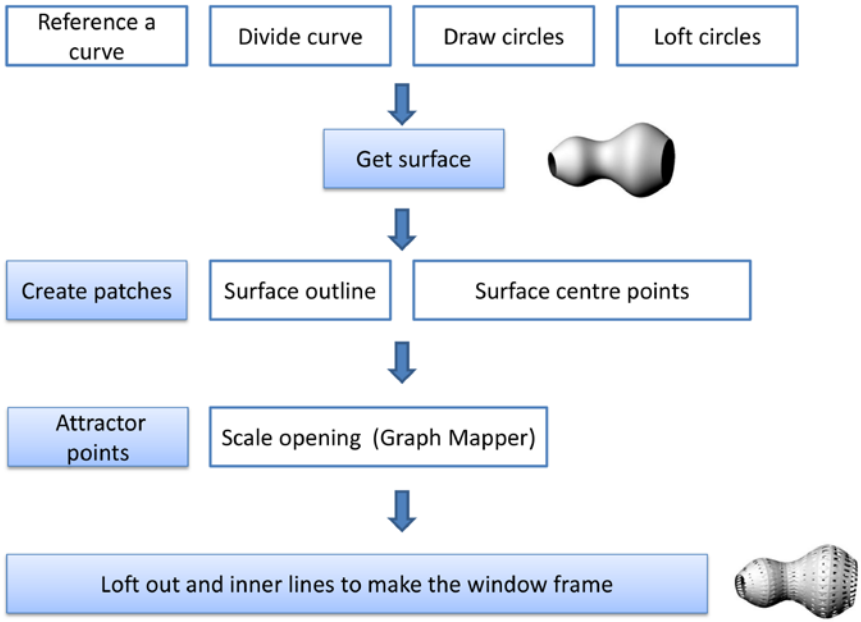
For the Grasshopper design, I chose a rectangular grid and cuboids- boxes, limited by curves- flows.

visual explanation

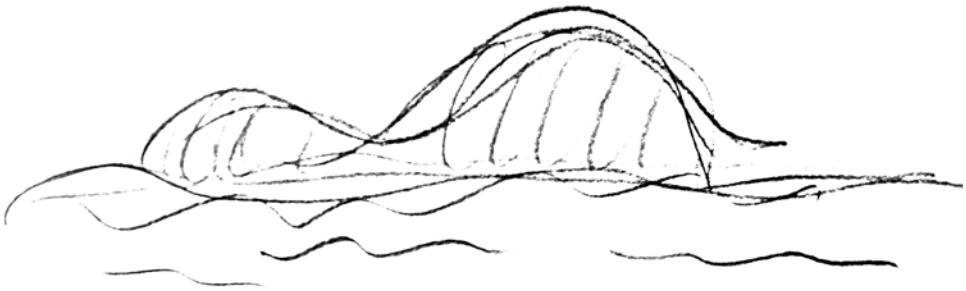




idea concept



conceptual draft



_ floating sauna

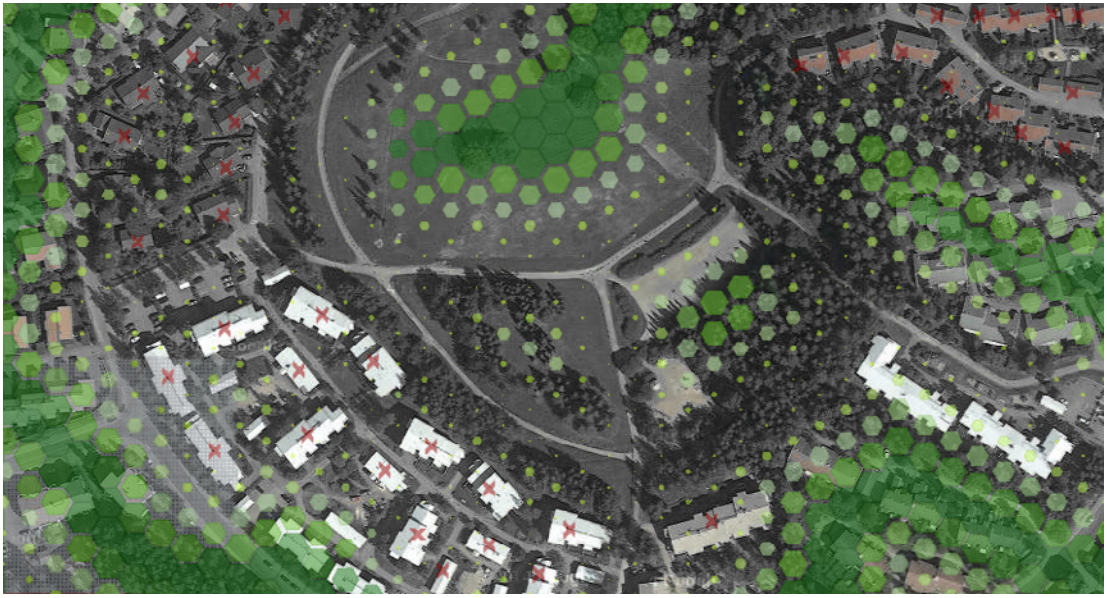
Lu Fan

As Tampere is famous for its unique geographic layout (located between two lakes) and sauna is the national hobby of Finland, I combined these two elements in my practice. First I chose Laukontori -a lakeside open-air market as the general location and devise a floating sauna which drifts along the lake. The shape of sauna is inspired by the hollow calabash, and the wooden structure is designed as a network of openings affected by the nearby attractor points, for instance important built-ups like bridges, market and stadium. When the sauna approaches to these points, the windows become larger to provide better views of the cityscape.

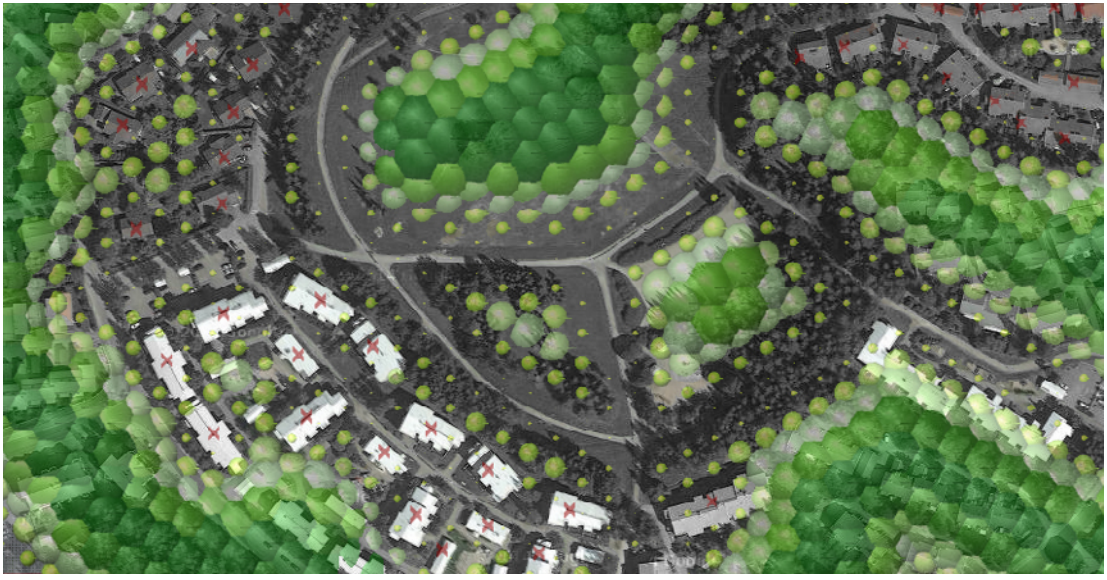
Technically, the basic curved shape of the sauna is made first by lofting the vertical circles arranged along the horizontal curve. Then the surface is trimmed into small patches with proper amounts. After this, the distances between the central points of each patch and the attractor points are evaluated as influential factors to affect the scale of openings.

idea concept

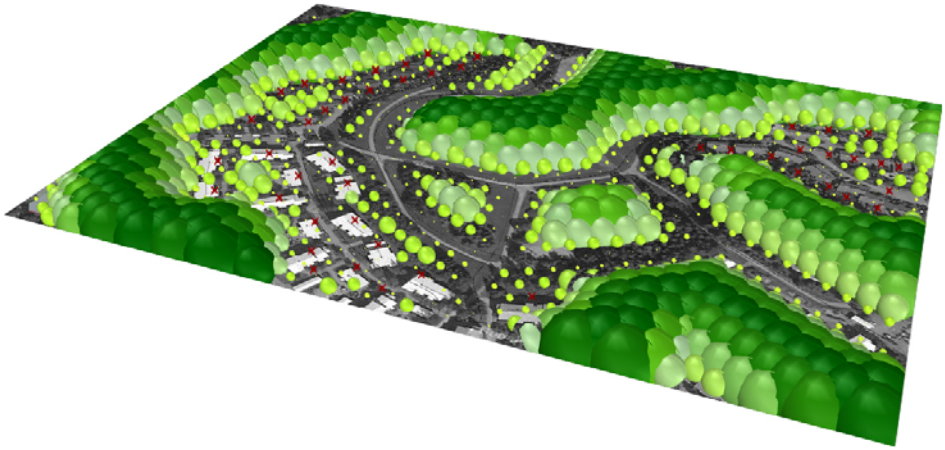
2D patterning

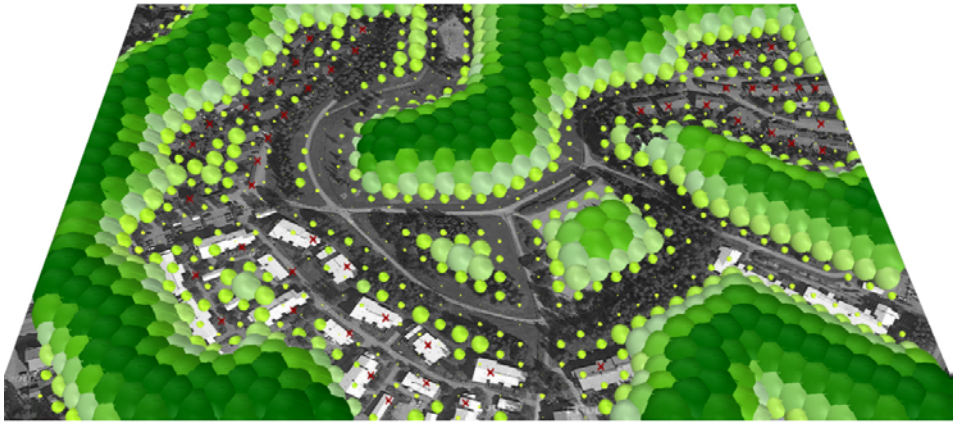


3D extrusion



visual explanation





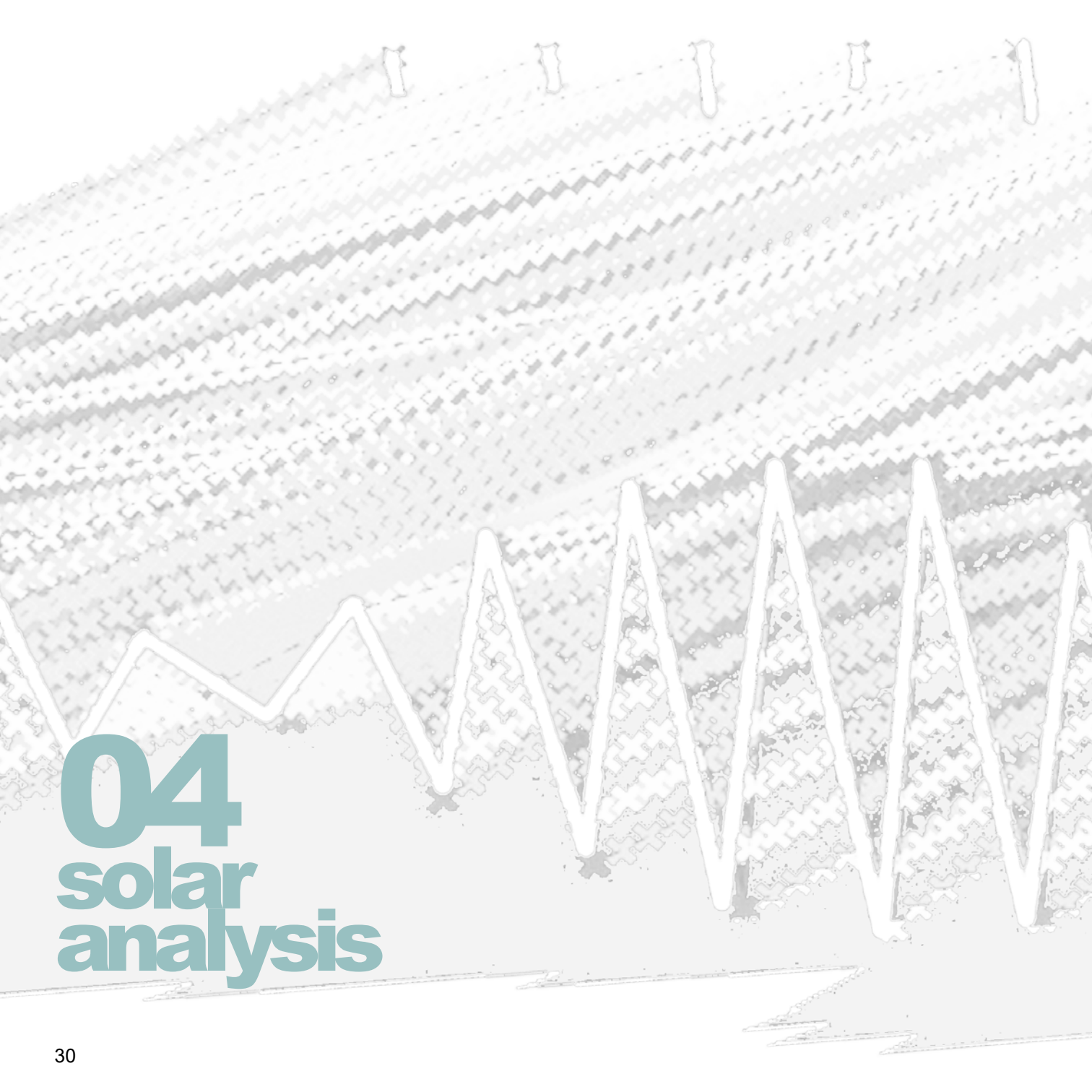
_ hexagonal cells

Juliana Padilha

The idea behind this algorithm was to identify areas in which landscape infill projects could potentially be implemented. In order to have the most productive results, a hexagonal grid was chosen. This choice was due to the grid's flexibility and efficiency of the hexagon shape in the perimeter/area ratio.

The area analyzed comprehends the south side of Hervanta and is predominantly residential. By defining roads as curves and each residential unit as a point, attraction parameters were defined.

Two variables influenced the size (and consequently also the color) of geometric shapes: the first was the distance between their central point and the attractor elements; the second was a Graph Mapper curve. The further from the attractor elements, the bigger the shape is and the darker is the color.



04 solar analysis

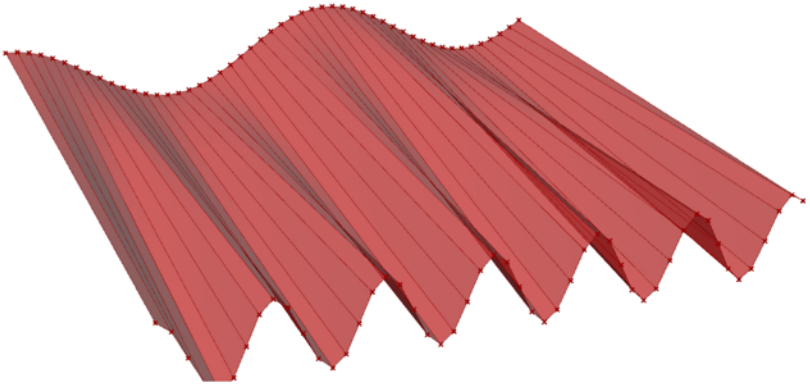
Using exercises done during the course, we analyzed the solar energy that falls on to our designs or to the terrain and pathways. The analysis was made on a specific day and time or it can span the range of several months/days/hours. As outcomes, we presented how solar energy looks for an entire year or day by day and how it could influence the design.

04

_authors

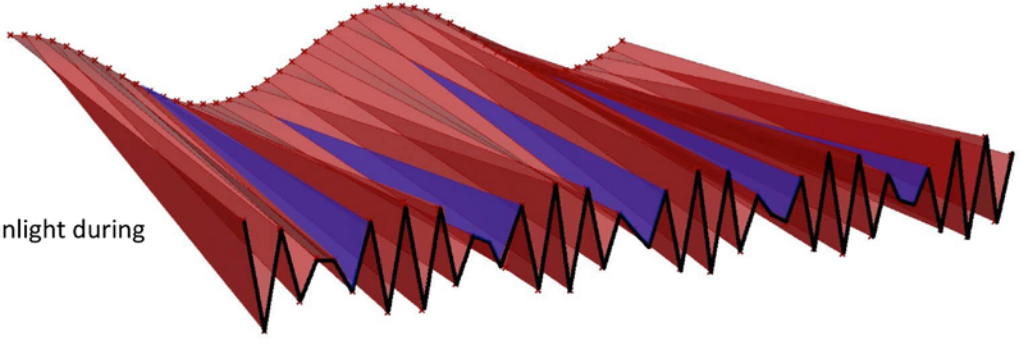
Roof

1 | Create 2 functions with different variables
2 | Create surfaces to the functions
3 | Connect to the solar vector
4 | Deconstruction surface
5 | Divide surface
6 | Add colour



What shape of roof it is
better to put solar panels ?

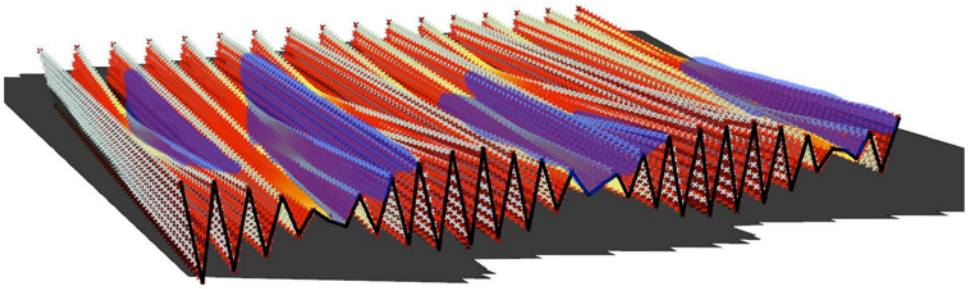
1st shape



roof part receiving sunlight during the most of the day

2nd shape

visual explanation



Last shape

roof part receiving sunlight during the most of the day

* Animation : analyze the sunlight during one day

reference

_ roof solar panels

Audrey Daudon

I created a roof and I added an idea concerning the solar energy. I wondered what the most interesting shape would be for the roof to receive daylight and use solar panels. I adjusted the shape of the roof after the solar analysis to reach a better solar panel placing scheme.

In this project, the shape of the roof is the consequence of the solar analysis. It is usually the opposite, where we place the roof and afterwards we think about where is the best place for the solar panels.

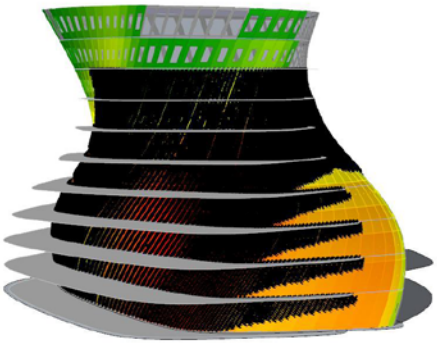
It allows exploiting them in the best way, and makes it efficient in the areas where they are not so exploitable like in Finland.

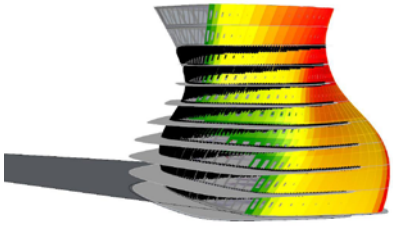
For a futuristic idea, I imagine a moving roof which is adapting during the day to receive the most of the solar energy.

idea concept

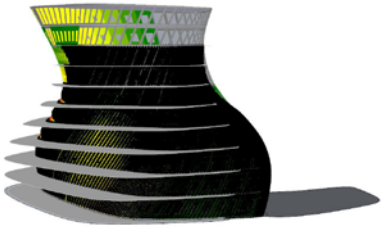
solar radiation

June



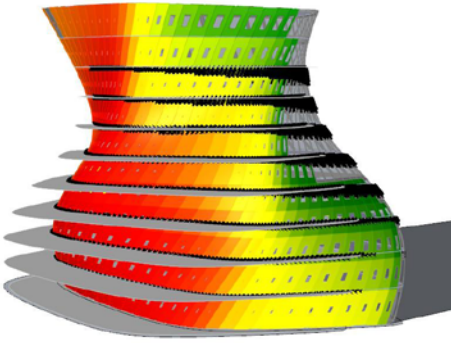


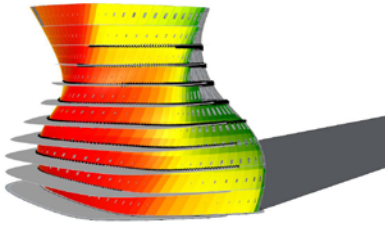
9 h



14 h

December





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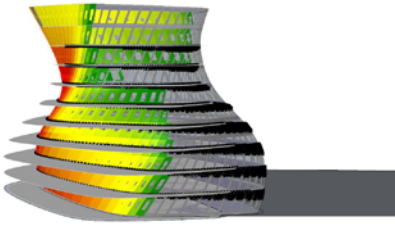
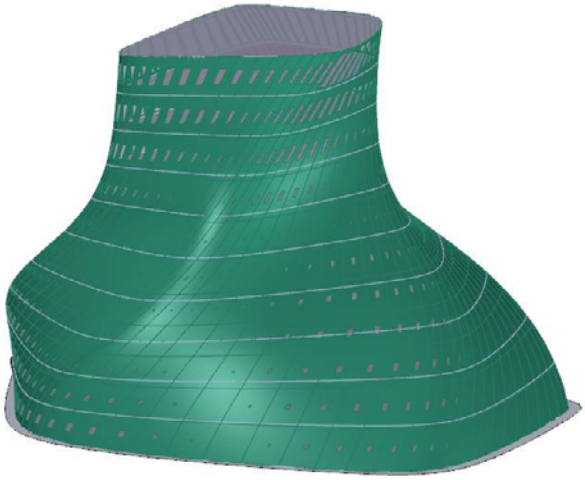
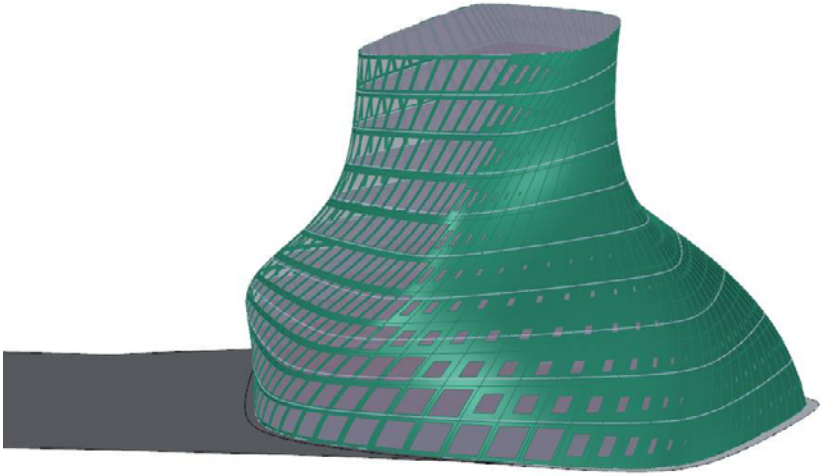


14 h

visual explanation

resized windows





_ arab world institut

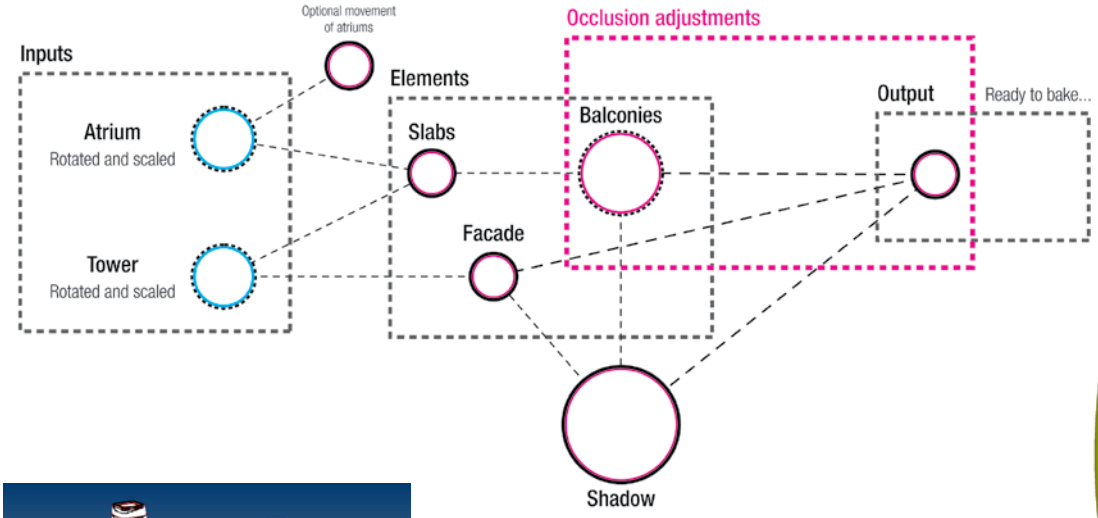
Manon Loup-Hadamard

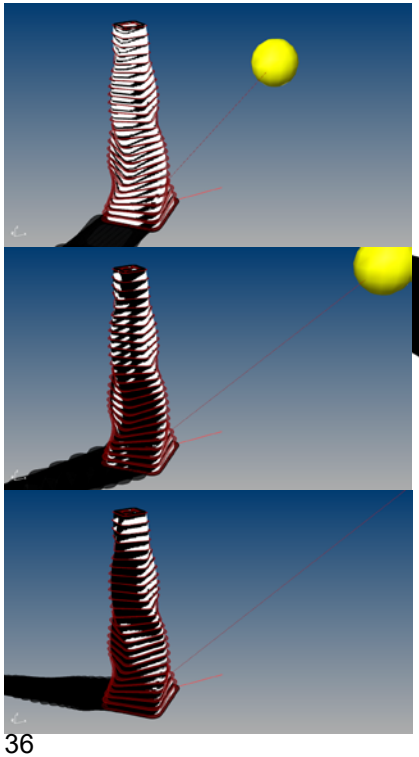
In this exercise, I tried to use grasshopper to study the modulation of the windows in a building.

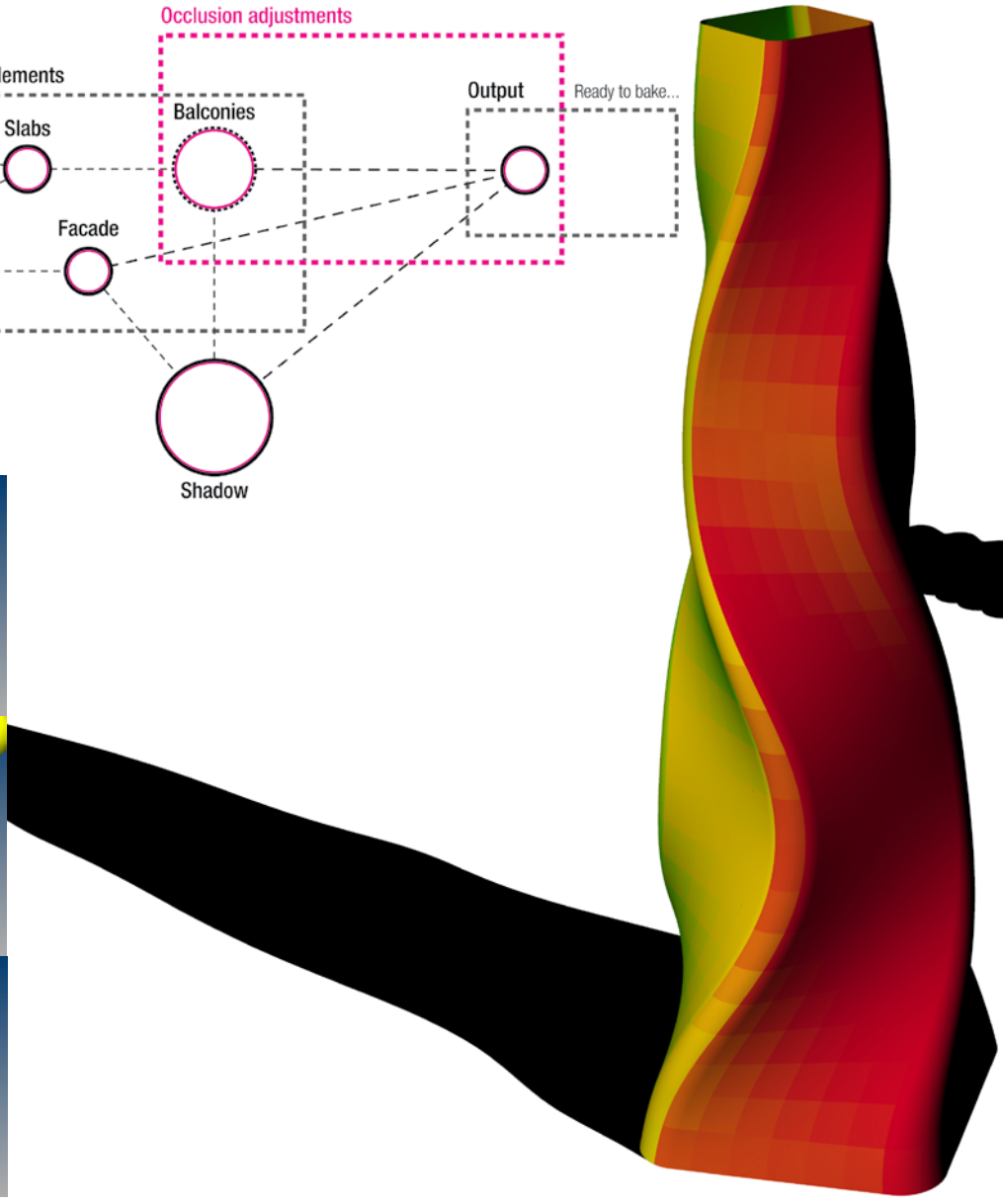
Thanks to Grasshopper, we can imagine to change the size of the openings in functionality to the orientation of the sun. The openings could be smaller when the sun is strong to limit the overheating for example, or even smaller on the North side to limit the loss of energy.

In the second design, I tried to understand how balconies can change the precedent analysis. In summer, the sun is very high; they protect very well the facade. In the case of Finland, during winter, the sun is so low that the balconies do not block the few hours of sun.

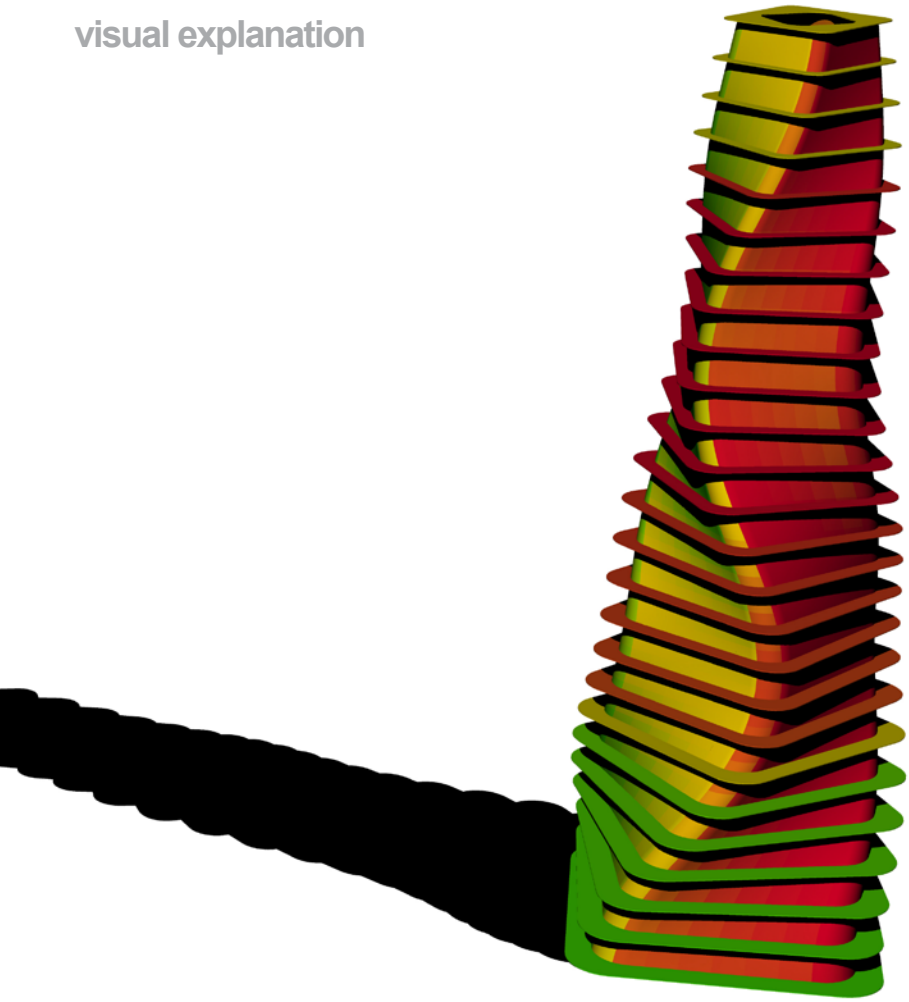
idea concept







visual explanation



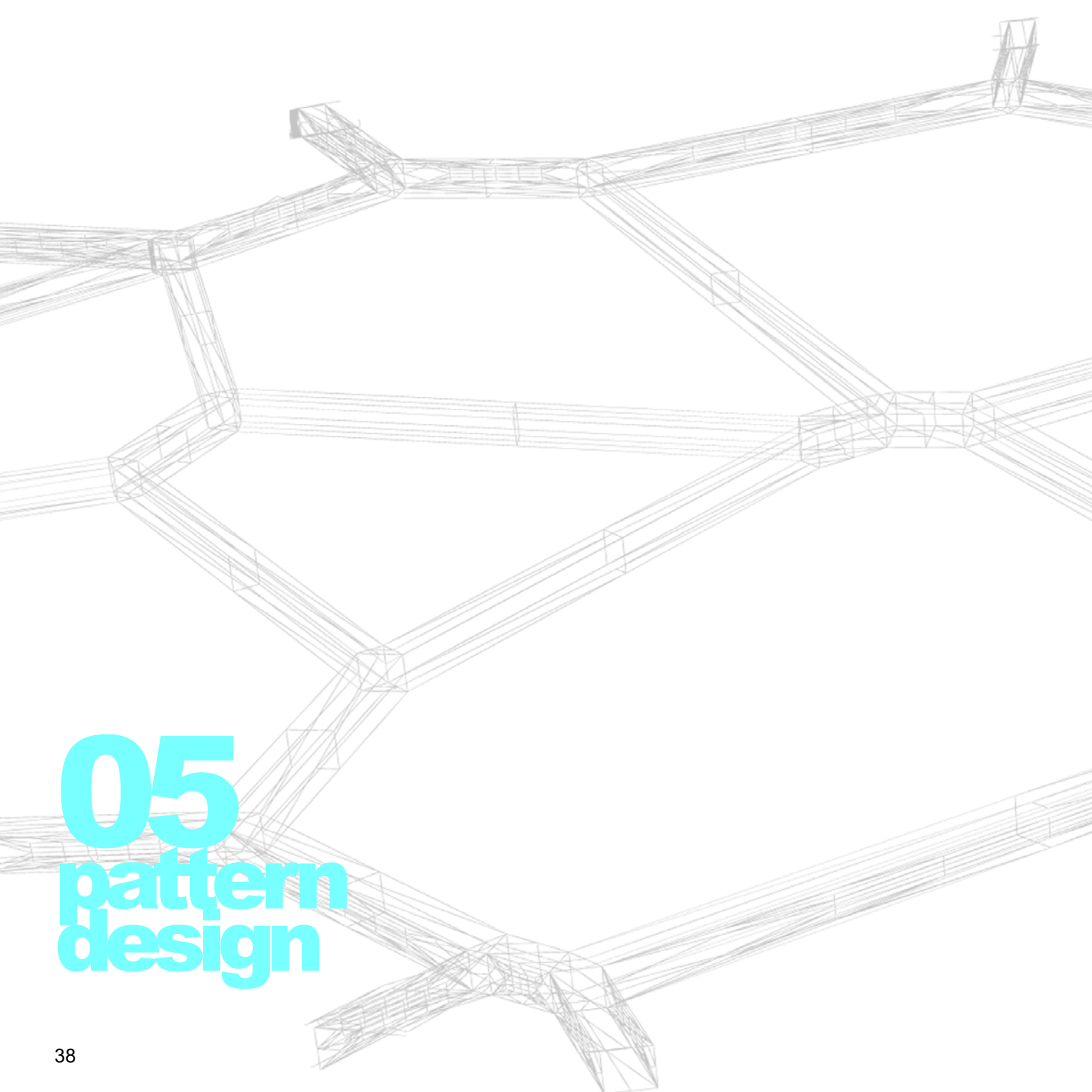
_ protective balconies

Nicolás Barrena

The solar occlusion exercise was a very interesting task in discovering a new method and tool to analyze accurately sunshine and shading.

What is even more interesting though is the potential interpretation of this information. The sun, being such an important element to human life, should have a big influence in the design process.
Other than shadow, such an analysis can define the balconies or the windows of a building and the distribution and circulation of a specific urban space.

In this exercise, I tried to reduce the solar impact according to the hours of light on the facades using balconies, which have increased the shadows.



05 pattern design

05

We were trying to explore the design possibilities of Voronoi, Delaunay and other patterns in small scale urban designs, keeping in mind the realistic scale of buildings and surroundings in the same time.

In this design task, we picked a location of our liking or used a given location for our design.

As final outcomes, we were trying to define our design characteristics through area, height, location, distance and orientation by creating algorithms.

_authors

idea concept

#01 Existing paths and trees

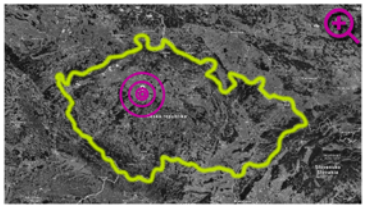
#02 Target design area

#03 Existing trees as centers of Voronoi Cells

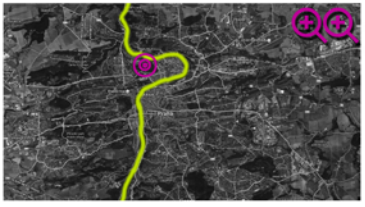
#04 New voronoi paths - Extrusion into tunnels

location

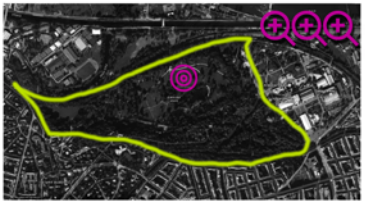
Czech Republic



Prague



park Stromovka



visual explanation

bird's eye view

perforation of the tunnels

_ interaction tunnels

Petra Moravcova

I chose a famous park in Prague for creating an interaction tunnel as urban garden furniture. I picked an area within the huge trees in the middle of existing paths.

I outlined existing trees as the initial points for voronoi cells, that were bordered by the pedestrian's paths. Referencing them to Grasshopper software I obtained a voronoi system of future pedestrian's park tunnels that were subsequently extruded upwards.

Using a pattern on the tunnel surfaces, I could use perforated metal cladding providing an amazing mediation of green surrounding.

idea concept

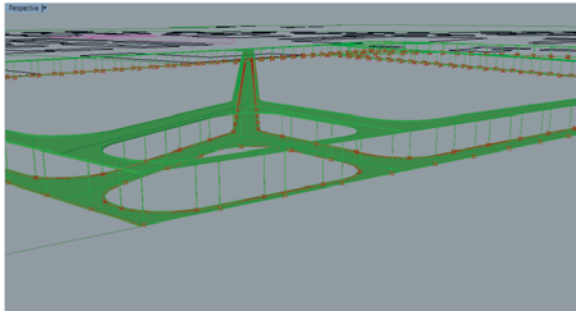
1. Smaller area means more densed.

2. Closest open area to the smallest part of Voronoi

3. Divide and scale

4. Fillet and surface

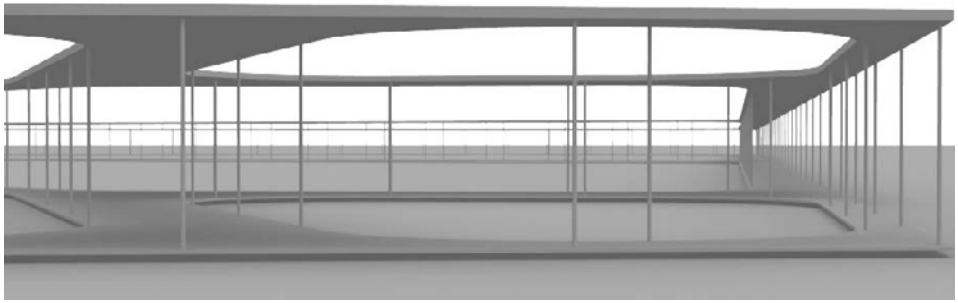
5. Place columns



3. Get the top and bottom with columns of the canopy

analysis of the area

perspective



_ pattern design

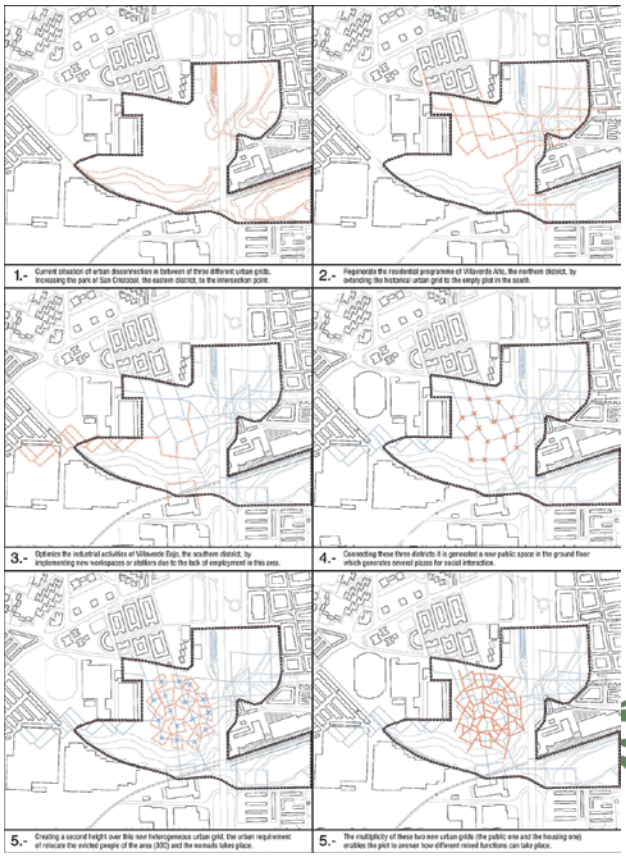
Hiroyuki Tsuki

For the pattern design study, I chose Tampere as my location. The definition in Grasshopper automatically finds the closest park to the area having the highest-density of public buildings.

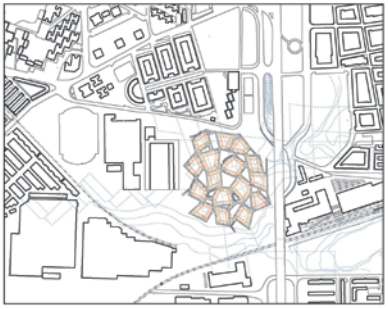
This means the park is one of the hottest open-areas in Tampere, so I decided to design a canopy in the area with another definition.

Voronoi composition out of points from public buildings implies hidden boundaries between the buildings, and the canopy could be the connotation of the hidden boundaries.

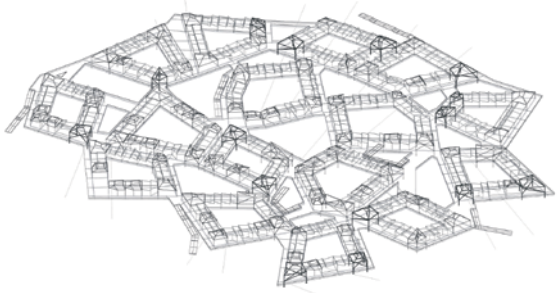
idea concept



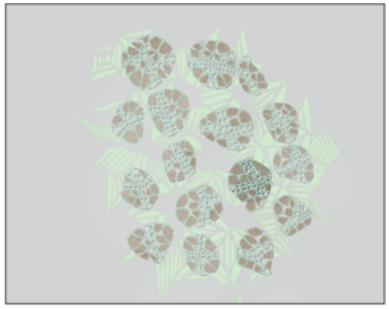
before-after plans

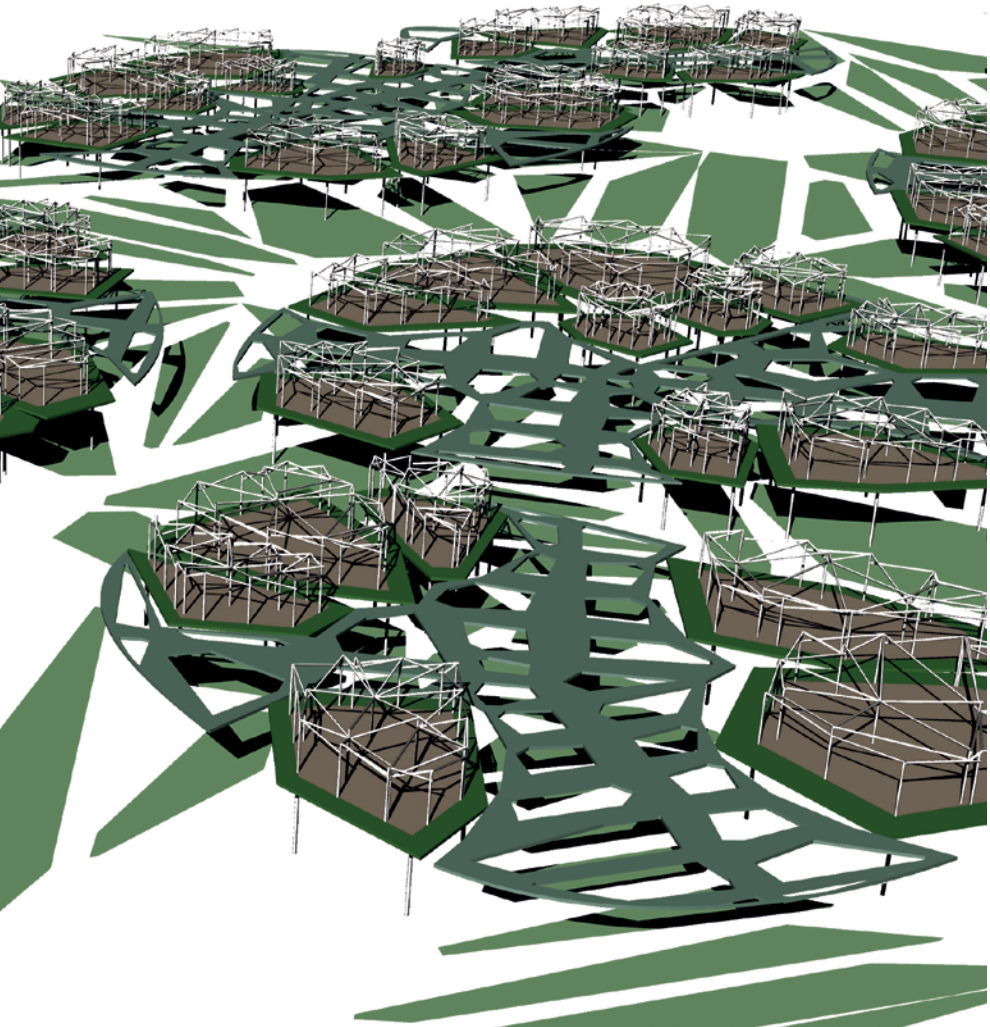


previous model



computational design model





_temporal housing

Nicolás Barrena

I explored the design possibilities of Voronoi in a small scale urban design.

The aim of this project was to explore and redesign a current project I have been developing in that moment, according to a new generative model based on Voronoi.

I develop the concept from a temporal housing project in Madrid, Spain. From the input data, including the extension of the urban grid, the existing blocks and the points of interest, the attraction points appeared and the voronoi pattern is created inside the border blocks.

I separated the green spaces and the playgrounds of the second floor from the public garden in the ground floor.

06 isovist analysis

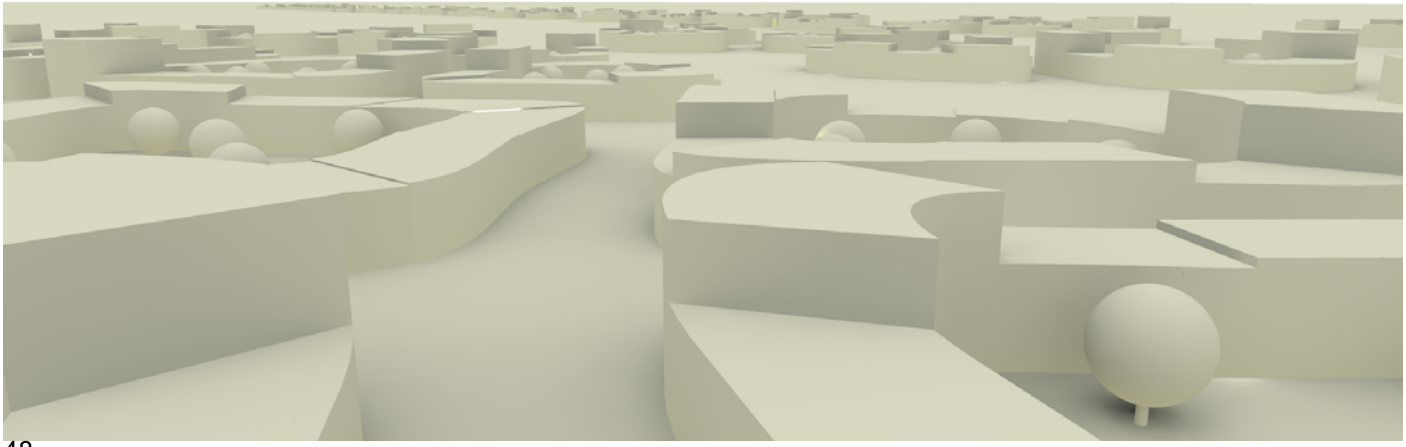
We created a visual isovist view analysis of one of our earlier urban designs.

We chose a significant open space, public square or pedestrian oriented public street, trying to imagine ourselves in that spot or walking along the route, how does the isovist analyze correlate with our image of that space- looking for optimal space for views, narrow pathways that offer privacy. For final outcome, we were trying to obtain design assumptions.

06

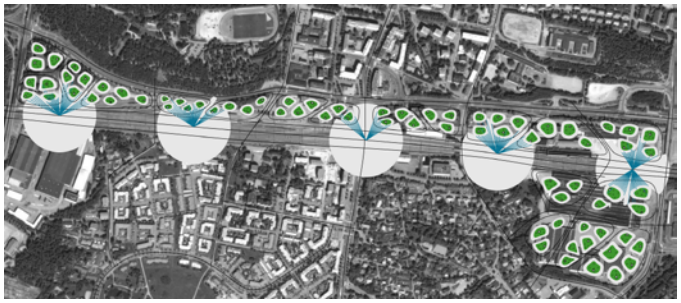
_authors

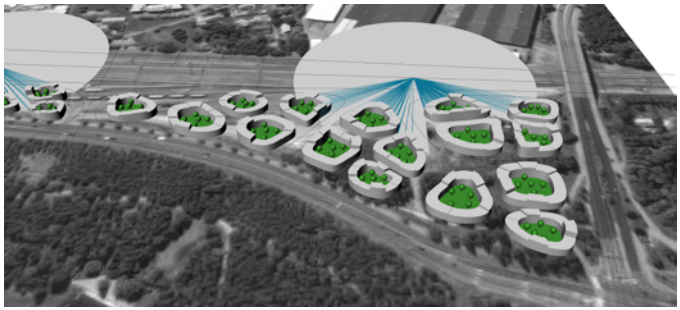
idea concept

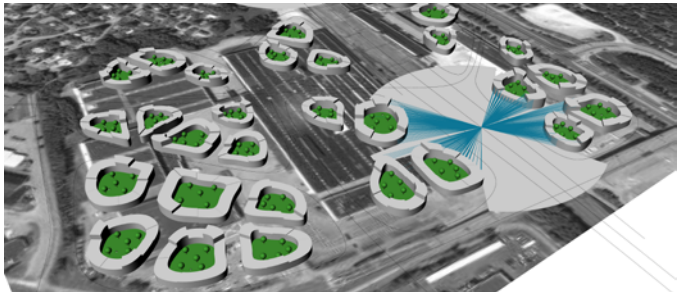


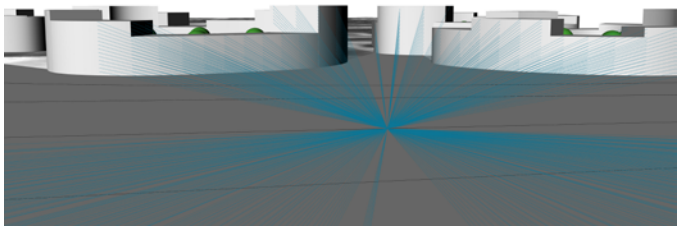
visual explanation

isovist analysis









_ along the trackside

Magdalena Klimczak

In 2012, the city of Lahti organised an ideas competition for the design of the railway trackside area in the city centre. I used the area to create a pattern design.
Firstly, existing roads and railway tracks were marked with curves. Secondly, areas for building development were created. Thirdly, Voronoi points were introduced.

Next, the regions were created based on area curves - too small areas were removed. After that, building bases were made through scaling the regions and cutting the sections. Later, the building bases were extruded along Z vector. Random heights were given using random surfaces and ‚surface primitives' - sphere and cylinder respectively.

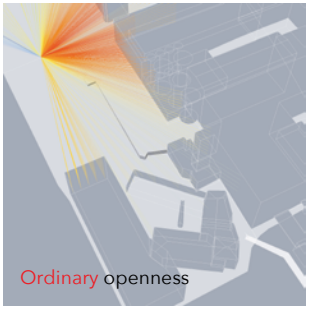
Isovist is a tool that can be very helpful in urban analysis. I tried to examine views that one can experience from the railway track.

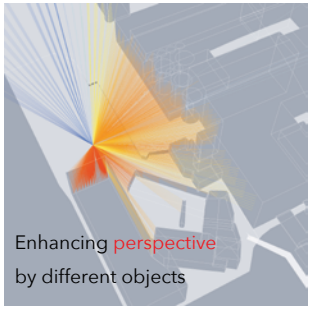
idea concept

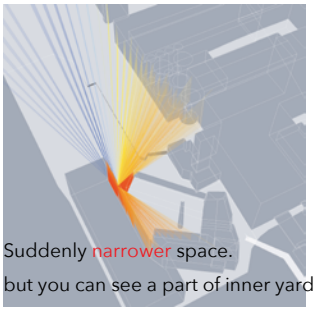
study of spatial sequence in Kehräsaari

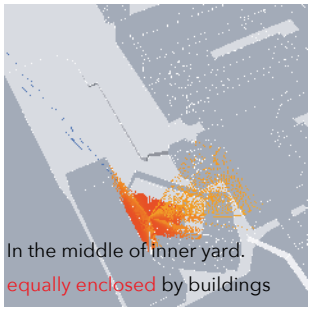
visual explanation

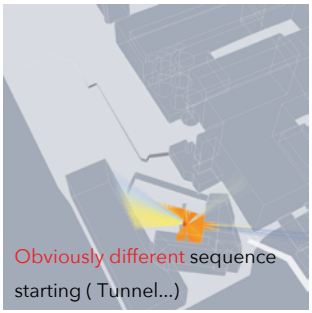
isovist analysis

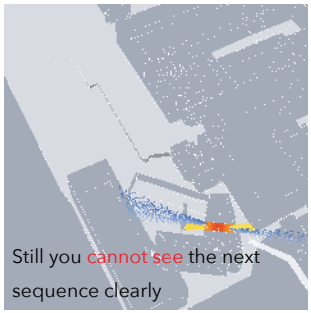


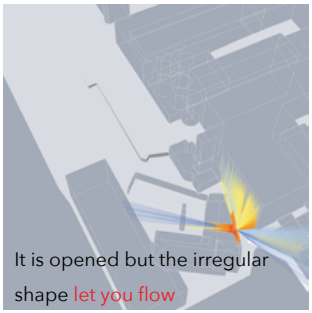












_ isovist analysis

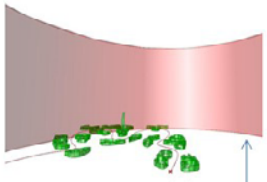
Hiroyuki Tsuki

For the isovist analysis, I chose Kehräsaari, which has interesting spatial quality with the historical context and its own unique building composition.

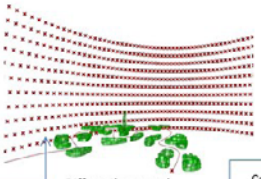
The three-dimensional Isovist definition visualizes how the space sequence changes and what kind of void the space has with different colors depending on the distance to the objects. In this tiny area there is a full range of spatial characteristics that is visually recognized by this definition.

If this could be applied to other places, it might show some typologies of interesting spaces.

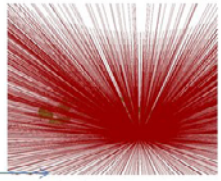
idea concept



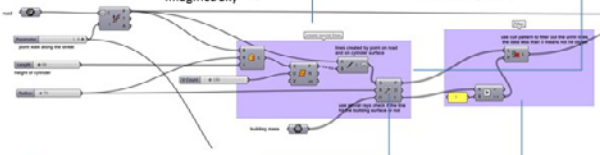
Cylinder as imagined sky

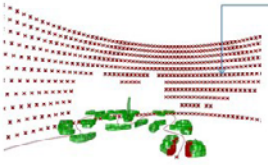


Diffuse the curved surface as points



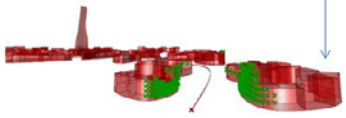
Connect these points with the observation point along road

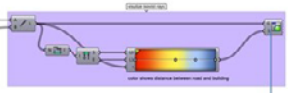


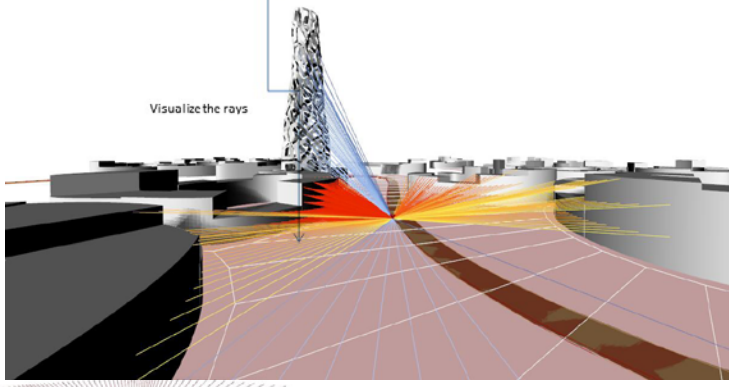


Use isovist check whether the lines hit the building

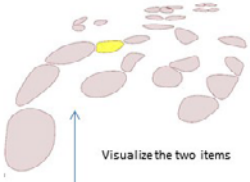
Filter out the "unhited" lines



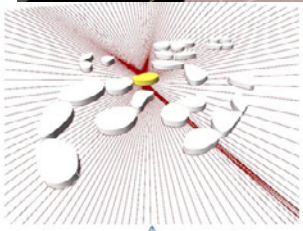




Visualize the rays



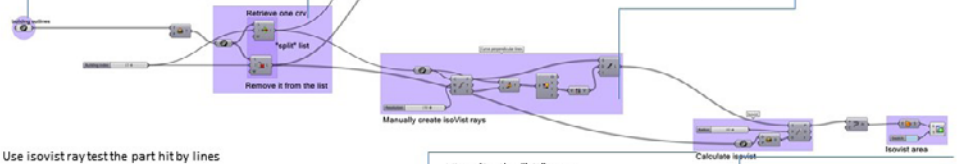
Visualize the two items



Building outline

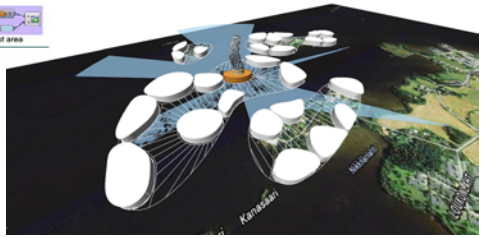
Retrieve the detected crv and get the remaining crvs

Manually create isovist curves by the perpendicular SDL lines



Use isovist ray test the part hit by lines

Visualize the "hit"area



strategy

visual explanation

_ isovist analysis

Fan Lu

The project is located in Nikkilänlahti, Tampere. There are two islands isolate from the peninsula. So the new plan is to create a new artificial island (white dash line) in the middle and link these islands with the mainland via a loop road (yellow line). Important points—existing buildings and potential public building are selected to define voronoi cells. With several steps, a new island community is built which comprises the cell-like blocks and landmark tower.

To evaluate the planning concept, I use isovist as a tool to test the visual distance from the street to the building nearby and the view-field of each block. First for the distance, a high cylinder is built surrounding the whole model, and then the surface is diffused as points. By connecting the observation point from the road with these points, the isovist lines hit the building surfaces it reaches. The color of lines represent the distance, red is near, yellow is further and blue is the furthest.

biography

Lu Fan

International master degree student at TUT since 2014.MSc. International Planning (University College London). Bachelor of Architecture (Dalian University of Technology).

Juliana Padilha Riekki

International Master student at TTY since 2013, has been studying architecture for 8 years. Graduated as architect and urban planner in the Federal University of Rio de Janeiro in 2012. One semester as exchange student at Technical University Berlin, Germany.

Audrey Daudon

Exchange student for the year 2015-2016 at TUT. Originally from France and studying in the school of architecture in Toulouse, in her 4th year of architecture studies, without including the placement years (2014-2015).

Magdalena Klimczak

Fourth year student from Łódź University of Technology (Poland), currently doing an exchange programme in School of Architecture at Tampere University of Technology. Previously, she did an International Baccalaureate programme lasting 2 years in Warsaw.

Peixuan Liu

A second-year international master degree student of TUT. In her 7th year of studying architecture. Bachelor's degree from China University of Mining and Technology. Photography and Painting as her spare time hobbies.

Ekaterina Ishimova

International Master's Degree Student in Tampere University of Technology, Finland since 2014; School of Architecture. Specialist's Degree in Architecture from Nosov Marnitogorsk State Technical University, Russian Federation 2008-2014.

Darina Bunak

Specialist diploma (6 years) by Saint Petersburg state university of architecture and civil engineering, Russia. 7 years of architectural practice in Saint Petersburg with the last two years as a customer representative at an international developer's office.

Danuta Kiedrowska

Exchange student in Tampere University of Technology in autumn term 2015. Bachelor degree from Gdansk University of Technology in Gdańsk. In her 5th year of architectural and urban planning studies.

Petra Moravcova

Exchange student in TUT during autumn term 2015. Currently in her 5th year of architectural studies. Bachelor degree from Czech Technical University in Prague. Next semester she is going to study architecture at Tongji University in Shangai.

Nicolás Barrena

International Exchange Student at TUT during 2015/2016. In his 5th year of studying architecture. Bachelor's degree from the Superior Technical School of Architecture, Madrid (ETSAM). He has been working nearly 3 years as an internship in different educational innovation collectives.

Manon Loup-Hadamard

International Degree student in the first year of Master studies at TUT. Bachelor's degree last year from the School of Architecture, Paris-Val-de-Seine (France).

Hiroyuki Tsukui

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B. A. Architect (University of applied science Cologne, Germany 2011). Assistant teacher of the Digital Design in Urban Environment course and international Master Degree student at TUT.

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M.Sc. Architect (University of Oulu 2010). Teacher of the Digital Design in Urban Environment course at the Tampere University of Technology.

autumn semester
2nd period
2015